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THE PROBLEMS OF THE PHOSPHATE FERTILIZER INDUSTRY AND THE DEVELOPMENT OF FERTILIZING IN AFRICA*

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document is a translation of an unedited original.

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I. INTRODUCTION

The fertilizer industry is currently going through a worldwide crisis.

In global terms, the supply of fertilizer is greater than consumption, a situation which, according to the forecasts of FAO (1986), is likely to outlast this century.

This is particularly true of the special case of phosphate fertilizer in Africa.

This situation is paradoxical, because, during the same period and according to the same sources, Africa will be increasingly affected by malnutrition: per capita food production declined by 9 per cent between 1970 and 1980 in Africa, whereas in the rest of the world it increased by 5 per cent.

The close relation between fertilizer consumption and increased food production no longer needs to be demonstrated, to the point where, according to a recent study conducted by FAO in 16 developing countries,* fertilizer can rightly be considered the spearhead of agricultural development. (1)

The purpose of the data and considerations put forward in this paper is to demonstrate that this situation is paradoxical in appearance only. However, it should first be recognized that the crisis affecting the phosphate fertilizer industry and fertilizing in Africa in general cannot be dissociated from that currently affecting the continent's agricultural sector as a whole.

Following a brief review of basic facts concerning fertilizer supply, requirements and demand - both potential and solvent - an attempt will be made to identify the main obstacles to growth in the consumption of this commodity by African farmers.

Proceeding from that basis, conclusions will then be drawn as to the implications for development strategies in the fertilizer industry in Africa and the concrete measures to be adopted at the various stages of the fertilizer supply chain in the African countries for the benefit of an expanding African agricultural sector.

II. PHOSPHATE FERTILIZER SUPPLY, CONSUMPTION, REQUIREMENTS AND DEMAND IN AFRICA

2.1. Mining and production of natural phosphate

The production of natural phosphate obtained in 1984 and forecast for 1989 in Africa accounts for 32-36 per cent of world production (see table 1).

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* Bangladesh, Brazil, Egypt, Indonesia, the Republic of Korea, Malaysia, Mexico, Nepal, Nigeria, Pakistan, the Philippines, Sri Lanka, Turkey, Yugoslavia, Zambia, India.

Table 1

Production of natural phosphate in Africa

(millions of tons)

	1984	1989*
N.W. Africa	27	41
N.E. Africa	11	21
S.W. Africa	6	9
Africa total	44	71
World production	138	198
Africa as a percentage of world	32%	36%

(Source: 2a.)

North-West Africa alone accounts for 20 per cent of world production.

Morocco is the largest exporter, while Tunisia processes 80 per cent of its own phosphate into fertilizer.

There are plans to expand or restore mining facilities at Khouribga (Morocco) and Sra Ouer ne (Tunisia), and - on a more modest scale - at Minjingu (Tanzania) and Sukulu Hills (Uganda).

Deposits in Burkina Faso, Mali and Niger are worked with very low intensity. Lastly, evaluations of phosphate resources have been conducted in Burundi and Zambia, while resources identified in Angola, Guinea-Bissau and Mauritania have proved the most substantial.

As shown on the attached map supplied by the International Fertilizer Development Centre (IFDC), Africa has many deposits and considerable mining capacity. Although the latter is mainly concentrated in North Africa, West Africa (Senegal, Togo) is also fairly well represented, and the same will soon apply to the African countries south of the equator (Zimbabwe and South Africa already having a significant mining capacity).

Table 2

Production of natural phosphate in West Africa

(millions of tons)

Senegal	1.9 in 1985
Togo	2.4 in 1985

Figure 1. Phosphate Deposits of Africa
(Source: IFDC)

2.2. Fertilizer production capacity and consumption

In Africa as a whole, phosphate fertilizer production capacity is well in excess of consumption of this commodity, whereas the production capacity for nitrogenous and potash fertilizers is below consumption levels (see table 3).

Table 3

Fertilizer production capacity (N, P_2O_5, K_2O), consumption and balance for Africa during the period 1984/85

(millions of tons)

	Supply*	Consumption	Balance
N	0.22	0.72	- 0.50
P_2O_5	2.44	0.58	+ 1.86
K_2O	0	0.28	- 0.28

(Source: 2b.)

Table 4 shows that more than half the phosphate fertilizer production capacity in Africa is to be found in Morocco, but, taking into account the levels of production achieved, only 20 per cent of that country's capacity was utilized in 1982/83.

Table 4

Phosphate fertilizer production capacity and extent of utilization (in percentage terms): 1982/83

(thousands of tons, P_2O_5)

	Capacity	Output	Utilization rate (%)
Algeria	165	48	29
Côte d'Ivoire	n.a.	3	-
Egypt	115	93	81
Morocco	1 485	296	20
Nigeria	20	7	35
Senegal	23	16	70
Tanzania	25	2	8
Tunisia	872	495	57
Uganda	-	-	-
Zimbabwe	20	15	75
Total	2 725	935	Average 34

(Source: 2b.)

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* Supply of N, P_2O_5, K_2O in the form of fertilizer, after subtraction of consumption in forms other than fertilizers, normal fluctuations in stocks, and losses connected with processing and distribution.

In overall terms, the production of phosphate fertilizers in 1982/83 accounts for only 34 per cent of the installed capacity.

What are the likely trends?

Many countries are installing additional production capacity:

In Morocco, the Jorf Lafsar complex will produce 1 million tons of DAP, 400,000 tons of TSP and 200,000 tons of ammonium sulphate phosphate (domestic market);

In Tunisia there are two projects, M'dilla and La Skira, which will produce 400,000 tons of TSP and 330,000 tons of DAP and complex fertilizers;

In Egypt, the Abu Zaabal complex will increase its phosphoric acid production capacity by 65,000 tons per year;

In Senegal, since 1983, 264,000 tons of phosphoric acid and 693,000 tons of sulphuric acid have been produced in factories, part of this output being used for the production of 165,000 tons per year of DAP, 224,000 tons per year of TSP and 80,000 tons per year of various types of complex fertilizers. The fact that the remainder of the acids produced is intended for export gives rise to severe financial and marketing problems in current market conditions.

Many other countries have plans for setting up factories: in Nigeria (project postponed to 1988/89), in Uganda (80,000 tons per year of TSP) and in Togo, Ghana and Gabon, to mention only manufacturing plants for phosphate and complex fertilizers.

Also in this context, the forecasts for 1989/90 made by FAO clearly reflect a still greater surplus balance between supply and consumption in phosphate fertilizers in Africa, on the assumption, it should be stressed, that solvent demand for fertilizers is maintained at a comparable level.

Table 5

Estimated fertilizer production capacity (N, P_2O_5, K_2O), consumption and balance for Africa during the period 1989/90

(millions of tons)

	Supply	Consumption	Balance
N	0.73	0.94	- 0.21
P_2O_5	3.99	0.80	+ 3.19
K_2O	0	0.36	- 0.36

(Source: 2b.)

In conclusion it can thus be said that Africa has abundant phosphate resources which are widely distributed throughout the continent. According to the estimates of FAO, by the beginning of the 1990s Africa will account for 36 per cent (or 71 million tons) of world phosphate production, and will thus become the principal world producer, ahead of the United States, whose production will by that time be fluctuating around 65 million tons.

It will have a significant phosphate fertilizer production capacity - 4 million tons P_2O_5 equivalent - which seems to indicate a considerable surplus in relation to estimated consumption in the continent - 0.8 million tons P_2O_5 equivalent. This production capacity will, however, be less than one tenth (9 per cent) of world installed capacity (approximately 43 million tons P_2O_5 equivalent).

This very general situation of imbalance, which is disquieting for the future, calls for a more precise analysis of the current fertilizer consumption levels in the light of potential needs. In addition, there should be better identification of the demand expressed by the potential "clients" (farmers in Africa) and the reasons which prevent this demand being expressed in effective form.

As will be seen, Africa is not suffering from an overcapacity in regard to the production of phosphate fertilizers, but it does show a dramatic under-consumption of fertilizer products.

III. POTENTIAL NEEDS AND FARMERS' DEMAND FOR FERTILIZERS

Annexed is a survey carried out in 1983 by FAO on fertilizer consumption per cultivated hectare in 37 African countries: such consumption is in the region of 11 kg/ha of ($N + P_2O_5 + K_2O$) and 8 kg/ha of ($N + P_2O_5 + K_2O$)* if Swaziland, where the level of fertilizer consumption is exceptional (74N, $37P_2O_5$, $33K_2O$ kg/ha), is not taken into account.

In the same year Western Europe supplied 224 fertilizer units per hectare under cultivation, and Asia 168 units.

Table 6

Consumption of fertilizer constituents in kg/ha under cultivation in 1983

	Africa	Western Europe	Asia
N	4	109	127
P_2O_5	4	57	34
K_2O	2	58	8
TOTAL	10	224	169

(Source: 2b.)

While this comparison is revealing, it is rather imprecise - since it relates to continents which are geographically very different - as a basis for trying to determine potential fertilizer needs in Africa more accurately. It should be emphasized that such an exercise is inevitably in large part arbitrary, since

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* N: 3.4 kg/ha; extreme values 0 and 30.3.
P_2O_5: 2.8 kg/ha; " " 0 and 21.3.
K_2O: 1.4 kg/ha; " " 0 and 57.6.

it must be borne in mind that the 2,886 million hectares of this vast continent, the 52 countries involved, the extreme heterogeneity of settlement and the variety of physical environments and resources scarcely permit one to arrive at ideas and concepts which are of general application.

At the same time, we think it would be worth while to draw attention to some features of Africa (rural and urban) which should condition future expression of demand for fertilizers in the continent as well as the development strategy of the fertilizer industry.

3.1. The Africa of tomorrow and its potential fertilizer needs

Africa, which in 1979 had a population of 427 million, can expect to have approximately 828 million inhabitants by the beginning of the twenty-first century (5a).

This very high demographic growth (3 per cent per year) is accompanied by large-scale recent urbanization which is also very rapid, a factor which makes Africa fundamentally different from Asia.

In a recent survey (3) of the 47 African countries south of the Sahara, this explosive development trend is assessed.

	1950	1980	2010
Total population (47 countries) (millions of inhabitants)	176	370	954
Rate of urbanization	12%	30%	56%

Despite urbanization, the rural population, taking into account the high rate of demographic growth, will continue to increase (population multiplied by 1.50 between 1980 and 2010).

As a result of this phenomenon of urbanization, but also for reasons relating to history, environmental conditions (rainfall, endemic diseases, marginal soils) and access routes, Africa today has a great diversity of rural population densities, a situation which will be still more pronounced in the future (cf. figure 2).

This demographic evolution and this heterogeneity of settlement have already two consequences which directly affect potential African demand for fertilizers: a very high level of demand for foodstuffs, and a high risk of environmental degradation.

The very high demand for foodstuffs results from the curve of demographic growth. This demand is associated with a need for growth in agricultural productivity, a good indicator of which is given by the evolution in the relationship between the non-agricultural population and the agricultural population in each country. According to the survey mentioned above, while in 1950 a farmer had to provide food, in addition to his own subsistence, for 0.18 non-agricultural inhabitants, the ratio had risen to 0.45 in 1980, and would reach 1.21 in the year 2010.

At present agricultural productivity in Africa, with all the reservations made earlier with regard to such generalizations, is one of the lowest in the world, if it is assessed in terms of kilograms of foodstuffs produced per hour of agricultural labour.

2.1

The picture in the year 2000

Rural* population densities per km^2

< 2

2 to 20

20 to 100

> 100

* Population living in centres with less than 5,000 inhabitants

(Source: 3.)

For example, it is estimated in 1987 that, as regards cereals production, 10 hours per hectare per year of work are required to produce 10 tons per hectare of grain in the wheat-growing areas of Beauce; in contrast, in the savannah zone south of the Sahara an average of 100 days is required to produce 0.5 tons of grain per hectare: the productivity of labour in this African cereal-growing zone is thus in the region of one thousandth of what it is in the major agricultural countries of Europe or North America.

There are many reasons for this, but the almost total absence of inputs and equipment (mechanization) obviously acts as a major obstacle to the necessary intensification.

One of the consequences of the high rate of urbanization is also the change in the actual structure of demand for foodstuffs: more wheat, rice and maize, more fruit and vegetables, and more meat (particularly poultry).

Now the traditional patterns of nutrition (cf. figure 3) of the rural African populations south of the Sahara show a diet which is basically made up of starchy foods, very low in fats, and most often deficient in proteins except in the Sahelian stock-rearing zones.

Diversification and the necessary introduction of more demanding crops (maize in comparison to millet or sorghum) or more intensive ones (vegetables, proteaginous crops) should be taken into account in evaluating potential needs for fertilizer products.

The second consequence of demographic trends in Africa is the danger of degradation of soils and of the tree cover as a result of the fact that the dwindling availability of land eliminates the long fallow periods needed for their regeneration after years of exhausting cultivation (little or no organic and mineral replenishment).

This dwindling availability of cultivable land, particularly in zones of high rural population density, also leads farmers to cultivate vulnerable land which has traditionally been left uncultivated, so that erosion sets in, imperilling the surrounding terrain.

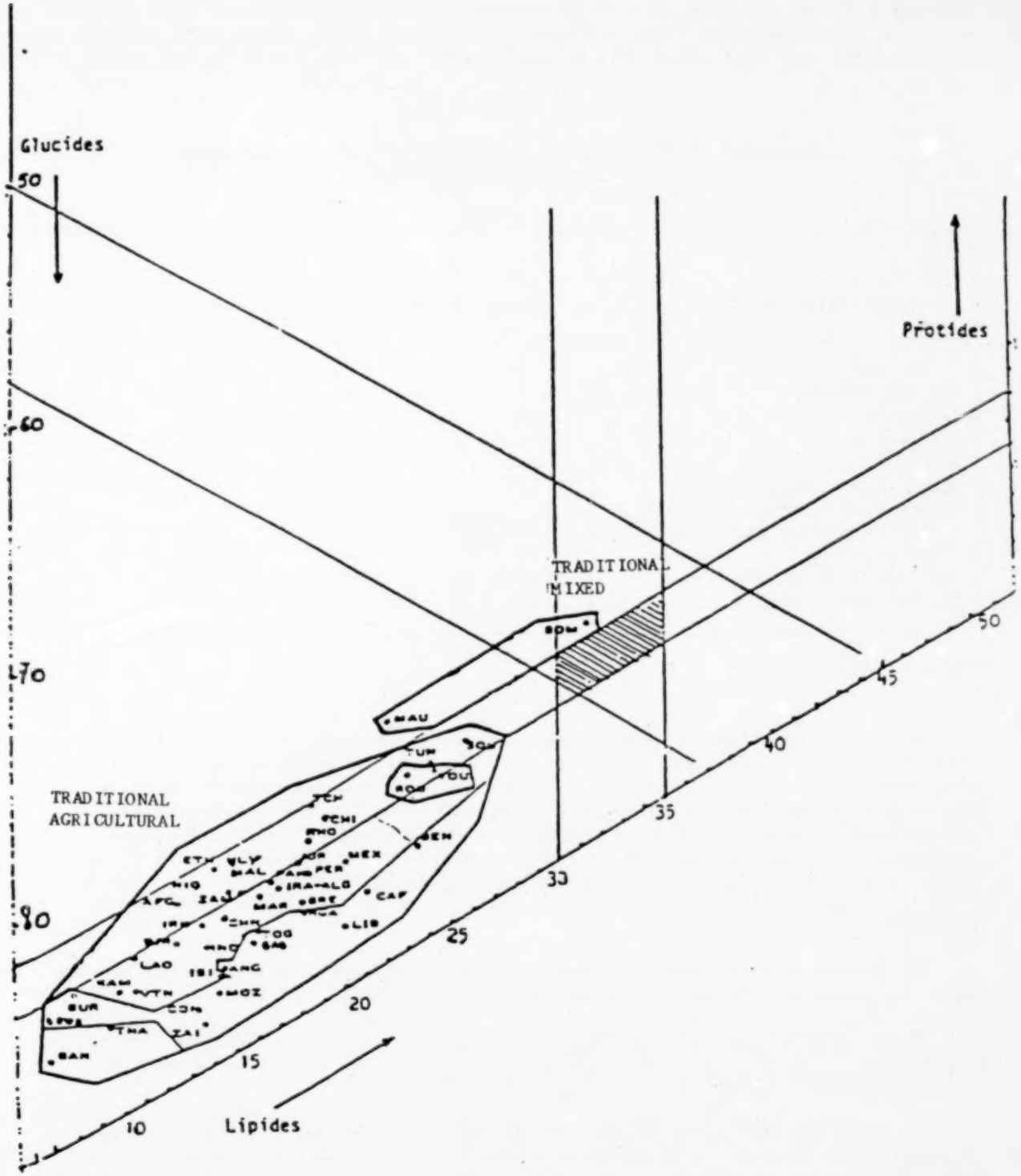
The study carried out by CIRAD, currently in course of publication (4), on fertility trends in the savannah zone south of the Sahara indicates that fertilization, by increasing the vegetable matter present per surface unit and by encouraging, under certain conditions, the accumulation of humus in the soils, plays a major role in the protection of African agricultural land.

In concluding this brief account it should first of all be remarked that it is not really possible or desirable to make too clear a separation between the problems of the phosphate fertilizer industry and those relating to the fertilization in general of soils and crops in Africa - or, for that matter, those linked to the utilization of other production factors (cf. table 7).

Secondly, it is no less evident that, in view of the current situation of African agriculture, its likely development and the three priorities which follow from these (intensification, diversification and protection), the potential fertilizer needs appear to be very considerable.

An assessment by country, climatic zone and type of crop-growing system can be made, and attention can be drawn in this connection to the interesting work carried out by IFDC in this field (6).

Figure 3. Traditional patterns of diet: nutritional triangle



(Source: 3)

In its study Agriculture: Toward 2000, FAO explores two scenarios - one favourable, the other less favourable - and takes the view that, in order to achieve its agricultural production objectives, Africa must increase the quantity of fertilizer applied to the fields by 8.5 per cent or 7.3 per cent annually between 1980 and the year 2000. This amounts to saying that by the year 2000 the potential phosphate fertilizer needs would be 4 to 5 times higher than consumption in the 1980s, and would thus fall between 2 and 3 million tons P_2O_5 equivalent.

Table 7

Estimated production factor requirements in the year 2000
(90 developing countries)

Production factors	Year 2000 A (Index. 1980 = 100)	Year 2000 B (Index. 1980 = 100)	A (per cent per year)	B (per cent per year)
Arable area	120	115	0.90	0.71
Irrigated area	141	129	1.72	1.27
Tractors	162	146	2.43	1.91
Fertilizer	553	417	8.92	7.40
Pesticides	514	412	8.53	7.33
Agricultural machinery	240	207	4.47	3.70
Commercial energy (in petroleum equivalent)	494	383	8.32	6.94
Improved seed	317	280	5.93	5.29
Cereals (livestock)	304	258	5.71	4.85
Labour (man/days)	146	137	1.91	1.60

(Source: 5a.)

It is also possible to make a very general estimate of how much phosphate fertilizer would be required to ensure that the total cultivated land in Africa (168 million hectares in 1980 (5a), an area which will be assumed to increase annually by a net 1 per cent) is able to provide food for the population of 828 million in the year 2000 (on the basis of an equivalent of 250 kg of grain per inhabitant, and taking into account the fact that an average of 1 kg P_2O_5 is required per 100 kg of grain produced). The estimate shows that 2.1 million tons P_2O_5 equivalent would be required. This is in line with the preceding estimate.

It should be noted that this would permit an average supply for each hectare under cultivation (205 million by the year 2000) of 10 kg of P_2O_5.

This average input of phosphate fertilizers is very low, since the preceding estimate is based only on crop requirements and does not take into account the initial endowment of the soils in this constituent.

In fact, agronomists consider that an average of at least 45 kg/ha of P_2O_5 is required to "correct" the deficiency in the soils of Africa. These cover at least 30 per cent of the cultivable area of the continent (7 - 1980). If such an additional supply was made available (over 30 per cent of the cultivated area in

the year 2000), this would lead to a new "potential requirement" of 2.8 million tons P_2O_5 equivalent, and thus to total potential requirements of 4.9 million tons P_2O_5 equivalent! From 1984/85 to the year 2000 it would therefore be necessary for the annual growth rate of phosphate fertilizer consumption to increase by 15 per cent, which is probably an unrealistic target in many countries.

In any event, such overall estimates are not primarily intended to provide the basis for a development strategy for fertilizers in Africa - for example, in zones in which the nature of the soils and the density of the rural population make it possible to identify the highest requirements for those inputs. They are rather aimed at posing the problem of fertilizer development in Africa, which is well illustrated by the example of phosphate fertilizers, which can be summarized as follows.

Africa produces phosphate fertilizers which are not purchased in situ. Yet this fertilizer supply corresponds quite well to the requirements of the African continent, which should indeed increase its fertilizer production capacity in order to meet the requirements of intensifying and diversifying its agricultural foodstuff production and of ensuring the protection of its land resources.

Accordingly, the principal question to be answered is the following: why do African peasant farmers make such little use of the fertilizers they are offered?

3.2. Difficulties affecting fertilizer use by African farmers

The previous question gives rise to others. The following fundamental questions arise with regard to phosphate fertilizers:

Is the proposed fertilizer properly suited to the soil and the crop: is it effective, does it have no harmful side-effects?

Are African farmers fully informed and aware of the role of fertilizer in enhancing the productivity of their labour in physical terms (yield) and in economic terms (income)?

Can African farmers purchase the fertilizer currently offered?

3.2.1. Agronomy

In response to the first question, numerous agronomic studies provide a rich harvest of experimental evidence regarding the effectiveness of phosphate fertilizing in Africa (cf. the scientific publications of the various national and international agricultural research institutes based in Africa). With reference to Africa south of the Sahara, emphasis should be given to certain particular aspects of the role of phosphates:

In contrast to the South American continent, which is geologically quite similar to the African continent, phosphate fertilizers are scarcely retrograded by irreversible physico-chemical fixation on the mineral colloids in the soil. With the exception of certain pedological formations found in the high Malagasy plateaux and in Central Africa (lateritic soils, highly desaturated or "gibbsihumox"), the phosphate fertilizers applied remain readily available to the crops. It is probable that the extensive geological movements - which flattened out the African substratum, particularly during the last glaciations - and the strong dominance of residual siliceous materials in the surface layers are behind this differential behaviour of soils in Africa (soluble silica tends to occupy the phosphate ion fixation sites).

Africa possesses extensive areas of soils that are acid or may easily be acidified (8) when they are brought under cultivation.

In agronomic terms, this means that the phosphate fertilizers have an appreciable residual effect beyond the first year of application, all the more so as the phosphorus is naturally not leached in the soil. Moreover, the soluble tricalcic natural phosphates are particularly suitable for the improvement of acid African soils (9). Even though they are less soluble than TSP or MAP/DAP, they often show very satisfactory annual effectiveness, even in low-acid Sudano-Sahelian environments, probably because of the low-concentration but continuous presence of silicic acid in the solution of sandy soils, which encourages the solubilization of natural phosphates.

Apart from this favourable indirect effect on soil acidity and aluminic toxicity, phosphate fertilizing (10) is also known for the part it plays in stimulating root growth (which is important in zones of water or mineral stress) and for its impact on improving symbiotic nitrogen fixing by leguminous plants, without the drawbacks (acidification, accelerated mineralization of organic matter in the soil) of nitrogen fertilizing, for example.

In conclusion, phosphorus is a particularly useful element for African soils and crops, without harmful side-effects. Quite the contrary - phosphate fertilizers have a clear direct and subsisting effect because most predominantly siliceous soils in Africa (quartz sands) are low in phosphorus and lack any appreciable phosphorus-fixing capability. In these frequently acid or easily acidifiable soils, soluble natural phosphates give good results.

3.2.2. The problem of fertilizer acceptance on the part of farmers

Although this is not always clearly expressed, many promoters of agricultural projects imply that there is still a great need for information and training for African farmers in the area of fertilizer use.

On the other hand, many agronomists working in the field consider that farmers no longer need to be convinced of the yield increase produced by (suitable) mineral fertilizers.

In view of these divergent opinions, the situation needs to be clarified by a closer analysis of the structuring of the rural sector in various categories of primary farming population. The SCET/BDPA report (11) on the formulation of a common agricultural policy for the West African Economic Community (WAEC) provides interesting data on this subject and there is reason to assume that they may be transposed to the entire African continent (cf. annex 2).

The authors show that the primary population may be broken down into three categories:

(a) The periurban primary population, brought about by the drift from the countryside to the urban centres. This segment, which accounted for under 3 per cent of the total primary population in 1950, will reach 30 per cent by the year 2010. This segment is very sensitive to market conditions and is a priori very favourable to any factor that increases agricultural productivity, such as fertilizer.

(b) At the other extreme, there are the so-called "marginal" primary populations (defined as those living 200 km from any major urban area) which of necessity adopt inward-looking modes of production and consumption and are, consequently, resistant to any innovation from outside. This segment, which still

represents 15 per cent of the total population of the ECOWAS States (and 30 per cent of the population of WAEC alone), will drop to a mere 3 per cent of the total population by the year 2010. However, more than 40 per cent of the rural population of certain States (Mauritania, Mali, Niger) will still fall into this "marginal" category by the year 2010.

It is clear that it will be very difficult or very expensive to achieve progress in productivity (and income) in these last-mentioned cases without an integrated subregional development policy.

(c) Lastly, the intermediate primary populations - the category of farmers currently in the process of intensification (e.g. the cotton-growing zone of West Africa) - are very open to intensive farming practices. In 1980 this group represented 50 per cent of the total population, a figure which will rise to over 60 per cent by the year 2010.

To conclude, although it was certainly necessary in the 1950s to carry out technical extension programmes to popularize fertilizer use in the countryside, where 30-40 per cent of the population was then made up of a marginal primary population which was not very open to technical progress, it has become unnecessary in the 1980s and 1990s to continue such a costly effort which really has no impact on the great majority of farmers who no longer need to be persuaded of the role of fertilizer use in increasing yield.

This does not mean to say that no more efforts need to be made to develop and disseminate more effective fertilizing practices (forms of application, spreading techniques) and fertilizer products suited to particular conditions (acid soils, dry regions, very intensive cropping, etc.) to enable the fertilizer to achieve optimum efficiency under peasant farming conditions (with the crucial problem of weed control when farming work is done manually or with little mechanization but fertilizers are applied).

This brief overview confirms that the reason for the low level of fertilizer consumption in Africa cannot be explained by agronomic causes related to the technical development of farming.

3.2.3. Obstacles connected with the economic environment

The development of agricultural productivity is directly linked with that of fertilizer consumption. As we have already seen, the only true potential market for fertilizers in Africa is for food products, where demand is increasing all the time. Even though industrial crops may receive more and better fertilizers, one cannot expect any great changes in the volume of fertilizer consumption for crop-growing systems that already receive generalized fertilizer application (90 per cent of areas under cotton in West and Central Africa receive mineral fertilizer) and in which one cannot reasonably expect appreciable expansion in future (international competition).

Experience over the past 25 years shows that, irrespective of food crisis situations in the countryside, which are less generalized in Africa than one might think, the motive force behind any trend towards increased productivity in agricultural production of foodstuffs in a country is not the search for national food self-sufficiency, but essentially the prospect for farmers of increasing their income and standard of living.

This finding is in line with the most recent analysis of the economic and food situation of developing countries made by macro-economists of international renown (5b). After noting the close link between individual purchasing power and

satisfaction of the food requirements of the inhabitants of developing countries, they have concluded that the main cause of malnutrition in those countries is not an inadequate supply of food products or production factors, but insufficient purchasing power. They then show that the most reliable and effective way to correct this situation is to establish a dynamic and prosperous rural sector to generate peasant purchasing power and a margin of self-financing in the sector at the lowest cost.

Four conditions then have to be fulfilled to develop a productive and profitable agricultural sector:

Establishment of a clear and voluntarist agricultural policy;

Existence of a logistic, commercial and financial (credit) infrastructure tailored to the rural sector;

Agricultural prices that are realistic and provide a return for farmers;

Availability of intensification "technology packages" suited to agricultural production conditions.

Until these four largely interdependent conditions are fulfilled it is unlikely that a peasant farmer will go beyond the satisfaction of his own food needs and take an interest in agricultural intensification. The latter will seem to him to entail too many economic risks which he alone will have to bear.

The problem of Africa is that, in most countries, the four conditions indicated above are still far from being satisfied. In this context there is certainly an obligation, or a temptation, for States to seek a solution, at the risk of increased dependence, in a strategy of imports or food aid aimed at the international market.

As a result of the charges levied on imports and the profits made from the sale of food aid products, this system may help to balance shaky budgets and satisfy urban dwellers accustomed to new food habits.

It has a certain logic and international aid must take it into account so that countries which really wish to break away from the apparently easy course of systematic food support and to commit themselves to a national agricultural policy aimed at food security are not thereby penalized compared with the others. We shall return later to the practical implications of this observation while nevertheless stressing the fact that there is a basic conflict between food aid of a systematic nature and the development of national fertilizer demand.

In the case of the countries choosing the "agricultural priority option" it is thus essential for the rural infrastructure to be improved and in some instances created: access and means of transport, organized markets, storage infrastructure, credit structure tailored to the nature and to the (climatic) risks of farm production (mutual guarantees by farmers' groups).

In this field, as in the field of agricultural policy discussed earlier, some suggestions will be put forward in the following chapter, but much has already been said and written on these complicated subjects affecting the entire process of agricultural development.

In our opinion, the essential point is that all proposals made regarding national or international structures should aim at increasing peasant farmers' income.

From the standpoint of the farmer who opts for a system of intensive food production, the required policies are clear:

> Among all the various intensification factors he needs (fertilizer, pesticides, improved seeds, machinery), the farmer must be able to acquire, in good time (the rainy season does not wait), suitable fertilizer (formulation, presentation) at the lowest possible cost;
>
> He must also be able to sell the surplus production brought about by his intensification effort at a price offering him a return.

3.3. General conclusions on fertilizer consumption and the development of agriculture in Africa

This analysis leads one to the conclusion that the problems of the production of fertilizers, and above all the phosphate fertilizers for which Africa possesses both raw material resources (raw phosphates) and a significant production capacity, are closely linked to those of promoting a productivist approach to agriculture in Africa.

At a macro-economic level and also from the point of view of the farmers' interests, the development of a prosperous and dynamic rural sector is considered by the experts to be the best chance for the economic development of the countries concerned.

There is therefore both a hope and a need to develop fertilizer consumption, currently very low, in Africa.

This development is possible because there is substantial potential demand among peasant farmers.

However, the farmers' current economic environment does not provide sufficient motivation for them to purchase more fertilizer.

In order to get the situation in Africa moving again, it is necessary to provide low-priced fertilizer and/or to increase the purchasing power of farmers, who must draw more profit from the sale of their surplus food production resulting from increased agricultural productivity.

In addition to a firm general policy by the State to promote national food production, it is important that farmers should direct this production without delay to the needs of urban consumers. In comparison with the rural food diet these needs differ in kind (grilled maize rather than millet gruel, rice, vegetables, etc.), presupposing a cultural diversification, and in terms of quality, presupposing the emergence of an industrial capacity for the processing and packing of farm products which will help add to the value of those products.

IV. FERTILIZER COSTS AND INDUSTRIAL DEVELOPMENT STRATEGIES FOR FERTILIZERS IN AFRICA

In adapting peasant food production to new urban demand, the fertilizer industry can hardly have a direct impact. It can and must, however, play a major role in reducing the cost of fertilizer delivered to farmers.

Many studies have been made on the cost of fertilizers in Africa, particularly under the aegis of FAO.

We include a summary table of fertilizer costs in 1985 from the point of manufacture or import to the farm gate (table 8).

Some examples speak for themselves:

Gambia buys urea on the international market at $100 per ton and the cost delivered to the farmer is $217; Zambia also buys urea on the international market, but pays $255 per ton and the cost delivered to the farmer is $422;

The N-P-K complex (16-16-16 or 17-17-17) reaches the Malagasy farmer at $343 per ton, whereas it costs $693 per ton to reach his counterpart in Rwanda.

Thus the cost of moving the product from the factory to the place of import and then to the distribution centres and to the consumers is enormous. It is generally far higher than the production cost of the fertilizer itself (1.5 times).

This situation has led several countries to establish systems of subsidies.

The recent study entitled "Role of fertilizer pricing policies and subsidies in agricultural development", FAO/FIAC, 1987 (1), makes a very interesting point regarding this controversial question of fertilizer subsidies.

The authors stress that there can be scarcely any doubt that, in countries where food security is really not ensured, the fertilizer subsidy to reduce the cost of this input to an acceptable level for peasant farmers remains a necessity.

However, the subsidies are now becoming so great a burden for Governments that, according to the authors, they must be reduced, if not eliminated, wherever this does not bring about a famine situation. This is frequently possible by reducing taxes, excessively high rates of interest or the exaggeratedly high transfer price of locally-available raw material (e.g. phosphates).

C. Fayard, taking this analysis further, shows that it is indeed possible, without a subsidized system, to make suitable fertilizers available to farmers at low cost. This objective requires only one condition to be met: an enterprise logic must be applied to the entire fertilizer branch.

Three production strategies are then identified: international, regional and national.

In the context of the great variety of situations encountered in Africa, each strategy has its benefits and its appropriate area of application.

In the case of countries which possess phosphate resources, it is argued that it may be technologically possible and economically justified to promote the emergence of a new fertilizer production or processing capacity either nationally or subregionally.

Starting from a proper analaysis of peasant farmer demand, identifying the types of fertilizer (particularly phosphate fertilizers) most suited to the soils and to the crops, taking advantage of the flexibility of small industrial installations which adapt better to variability in conditions of supply of basic raw materials or semi-finished products (DAP, urea, KCl, etc.) and thus reducing the investment costs and the logistic costs (location at or near the places of consumption), there seems indeed to be room for this new and complementary capacity for manufacturing diversified fertilizers intended essentially for internal national or subregional markets.

Table 8

Summary table of fertilizer marketing costs ($US per ton), 1985

	East and Southern Africa				North-East Africa		Central Africa		West Africa			South America	
	Madagascar (16-16-16)	Tanzania (Urea)	Zambia (Urea)	Zimbabwe (AN)	Somalia (Urea)	Sudan (Urea)	Rwanda (17-17-17)	Zaire (f)	Burkina Faso (15-20-15)	Gambia (Urea)	Ghana (AS)	Argentina (Urea)	Nicaragua (t)
Import (CIF) or ex-factory price	219 a/	240 a/	255 a/	164 b/	215 b/	138 a/	252 a/	241 a/	318 b/,g/	100 a/	103 a/	107 b/	226 b/
(For land-locked countries only Marketing costs to the border)	-	-	75	-	-	-	173	-	27	-	-	-	-
Transport costs	56	124	47	20	17	40	41	44	41	11	42	12	67
Storage costs	5	2	8	-	6	8	59	17	...	6	4	3	...
Handling costs	10	14	7	4	7	9	2	1	6	4	15	3	21
Physical losses	6	2	4	2	14	5	19	22	-	7	3	1	4
Taxes and levies	1	-	-	-	1	46	5	15	20	-	-	6	-
Interest costs	9	37	5	2	-	-	79	-	-	6	18	6	18
Promotional expenses	-	-	...	-	-	-	-	1	-	1	-	-	-
Other costs	14	3	4	7	1	1	3	1	-	12	2	-	-
Importers'/ wholesalers' margin	10	39	-	13	11 d/	56	36	6	10	40	14	10	7
- Retail margin	13	25	17	30	-	e/	24	e/	-	30	9	-	41
TOTAL MARKETING COSTS	124	246	167	78	57	165	441	107	104 h/	117	107	41	158
Total cost	343	486 c/	422	242	272	303	693	348	422	217	210	148	384
Retail price	286	Variable	243	242	239	303	489	348	296	202	109	148	384
Subsidy	57	-	179	-	33	-	204	-	126	15	101	-	-

Notes: - = nil, ... = negligible.
a/ Import (CIF) price.
b/ Ex-factory price.
c/ An additional charge of $49 is made on imported fertilizer to support high production costs of TFC.
d/ All fertilizer in Somalia is distributed on an ad hoc basis by FAO and other projects which absorb some costs. The margin quoted is nominal.
e/ Included in wholesale margin.
f/ Average of all imports.
g/ Ex-factory Abidjan, Côte d'Ivoire.
h/ Probably understates true costs, which are absorbed by the cotton marketing organisation, SOFITEX.

Consequently, in an "ascending" approach to the question of the fertilizer industry in Africa, i.e. starting from the real demand on the part of potential consumers, and not a "descending" view which imposes a logic and constraints peculiar to heavy industrial structures, one arrives at the conclusion that, to deal with the variety of rural development problems in Africa, there must be an equal variety of industrial solutions "offering technologies, products and services of varied and appropriate size". (12)

What answer can one give to those who consider that the emergence of a national or subregional production or processing capacity (which may mean rehabilitating or restructuring existing production capacities) implies a reduction in fertilizer exports to those countries?

While such a conclusion may seem self-evident, we think that a situation similar to that noted in regard to the cereal trade during the 1970s may be expected. Kellog (1985, quoted by Dorfman and Falcon) has provided extremely interesting evidence that those developing countries having chosen to give priority to agriculture are in fact those which make most use of world trade in food products.

Considering the technologies envisaged (complex partial attacks) in these new industrial installations, the vast potential fertilizer requirements, the development of new, demanding crops and the increase in cropping intensity (several crops each year from the same field, e.g. market garden crops), it is very probable, on the contrary, that the consumption of raw materials, semi-finished products and complex fertilizers purchased on the international market will not diminish but rather increase appreciably.

To bring this chapter to a close, it must be reiterated that, in the case of those countries which are firmly committed to agricultural intensification and increasing peasant farmers' income, nothing can be decided or undertaken in the area of fertilizer industry development without a global, multisectoral and imaginative approach to the entire fertilizer branch.

This approach starts with the farmers, that is to say with the fertilizer consumers. As with any product that one wishes to sell, it is necessary to start with a serious "market study". The target population is diversified, professionally unorganized, sometimes up against crisis situations and changing constantly, and motivations are not well enough known to all those participating in the countries' fertilizer policy.

It thus seems essential that peasant farmers should organize and develop professional structures and make their voice heard.

It is also important to have a place for the collection of all information needed in political decision-making. This must be provided nationally and subregionally since there are many complementarities at the latter level relating to demand, production and consumption of farm products and fertilizers (and other inputs).

It is also at subregional level that it is easiest to solve problems concerning relations with the outside world, whether with regard to food aid, customs protection or regulation or regional and international financing.

A dynamic approach to the problems of fertilizer production also presupposes that all means will be used to identify, train and support managerial personnel in Africa who will be able to promote a business-like approach in the fertilizer industry.

V. RECOMMENDATIONS

These recommendations concern three objectives:

Better evaluation and stimulation of national fertilizer demand;

Optimization of production and processing capacity for fertilizers in order to meet demand (nationally and, above all, subregionally);

Reorientation of international aid in favour of aid to the factors and conditions of production to ensure optimum utilization of fertilizer by agricultural producers.

In general, these objectives will be pursued by supporting, on a contractual basis, initiatives taken at the most elementary possible level.

As has been mentioned several timess, there is a great diversity in the situations in African countries and their agriculture and the few suggestions set out below are above all intended to provoke thought and encourage concrete proposals rather than to impose a particular view without discussion.

(a) The national level

- Promotion of "Producer groups" (PGs) established around a common production objective (maize marketing, improved seeds, etc.). Each PG is organized on the basis of a village or a few villages bringing together about 100 persons, or about 100 hectares on which some 100 kg/ha of fertilizer are used - 10 tons per year of fertilizer per PG and 1,000 tons per year for 100 PGs.

  This will allow the emergence of profitable secondary activities in each district or administrative division: small local transport enterprises (from the district to the PG) with 5-10 ton lorries working 150 days/year to carry fertilizer (and other goods the rest of the time), small enterprises to provide services relating to storage, milling and processing and packaging of products to meet local and regional food requirements, small mechanical workshops, etc.

  Heavy transport for supplies (and removal of heavy products for marketing) to the local districts from the fertilizer factory or place of import will be provided by national-scale transport enterprises (30-40 ton lorries).

  Establishment of an assembly of PGs in each small homogeneous farming region (cotton region, maize region, etc.) bringing together:

  The chairmen of the PGs;
  The representatives of the local public authorities;
  The haulers and traders.

  At these assemblies fertilizer needs can be assessed and the PGs will undertake to buy the quantities of fertilizer needed, making it possible to fix, in compliance with administrative rules, the cost and time-table of fertilizer transport on the basis of a mutual contract between the parties involved.

  At this level an agricultural co-operative credit will be organized, based on the principle of mutual guarantees at the level of each PG (or secondary farming enterprise).

- Organization of a National Fertilizer Agency (NFA) to gather all information necessary for defining and adapting a national fertilizer strategy. These data will be collated according to norms which, if not unified, are at least coherent as between the various countries of a subregional grouping. The fertilizer industry will be associated with the work of the NFA according to rules fixed in each country.

(b) The subregional level

A subregion is taken to be a group of countries with complementary interests, representing both a market and a capacity for credible proposals vis-à-vis bilateral, multilateral and international aid and international trade.

We think it necessary for the efforts of the NFAs to be federated at this level to make it possible to draw up a coherent subregional strategy.

We propose that organizations such as WAEC, ECOWAS and the Entente Council should set up Regional Fertilizer Agencies (RFAs) - a sort of specialized committee for the fertilizer sector. Here would be located the necessary computerized facilities for the acquisition, processing, publication and dissemination of collected national data, and the necessary means for mobilizing expertise (independent experts) to assist requesting countries in the area of fertilizer use, manufacturing technology and fertilizer distribution and marketing.

The eventual objective would be, on the basis of these RFAs, to establish for Africa a structure comparable to that which has proved its usefulness in the countries of Asia and the Pacific ("Fertilizer Advisory, Development and Information Network for Asia and the Pacific", FADINAP).

Finally, at national level with regional co-ordination, certain problems would be studied, broken down and treated locally or under co-operation agreements.

We shall cite the following, without giving an exhaustive list:

In the area of research (agronomy and technology): (1) development of new fertilizer products that are inexpensive and meet the requirements of the domestic markets; (2) diversification of crops with a view to their better adaptation to urban requirements; (3) development of equipment and workshops to process and package marketable food production.

In the economic field: development of customs systems or systems to regulate trade in imported food products, selection of ways of reducing regional logistic costs, identification of "regional terminals" for the import of raw materials and semi-finished products taking optimum advantage of world market fluctuations, etc.

In the area of training, highest priority for training in the management of industrial and commercial enterprises in the fertilizer branch.

(c) The international level

Two topics merit closer attention:

- Is it possible to replace food aid by an aid for the development of fertilizer consumption which is satisfactory for States and for the various economic agents in the fertilizer branch?

  Regionally, it is certainly necessary first to provide a system of food security to cope with unpredictable crises (droughts). However, we are not

in favour of fertilizer donations or a more or less generalized system of subsidies (from the factory to the farmer) whose object is often to maintain an inadequate fertilizer branch. The idea would rather be to give supplementary facilities to countries and individuals seeking to increase fertilizer consumption, by various modalities: complementary loans granted to dynamic private entrepreneurs (fertilizer production, distribution) on the basis of a programme of satisfying national or subregional requirements and under financial conditions granted in the public domain, donation of raw materials or semi-finished fertilizer products to processing shops, access for PGs to production factors that will bring about greater efficiency of the fertilizers they purchase (fungicides, selected seeds), etc.

Thought should be given at a general level to such proposals, the aim of which would be to give a technical premium and sometimes a financial premium (loan) to fertilizer users, so that they may reap more benefit therefrom.

- The problems of the fertilizer industry, particularly the phosphate fertilizer industry, result from the fact that consumers do not have sufficient purchasing power to buy this input which is essential to the agricultural development and intensification that Africa needs.

  This touches on numerous macro-economic, micro-economic, technical and infrastructure conditions. In short, it is a complicated matter and there may even be no possibility of a durable solution if these problems are dealt with in an isolated or sequential fashion: agricultural techniques, industrial problems, commercial and financial problems, etc.

  It would thus seem useful, in clearly identified projects, to ensure still more functional co-ordination between the different international agencies, particularly FAO and UNIDO, to enable specialists with varying backgrounds and from varying disciplines to work more effectively for the agricultural development of developing countries.

  In this context there is an evident similarity between the problems encountered in the area of fertilization and the use of fertilizers to enhance soil fertility and productivity and those encountered by WHO: pharmaceutical products and medical care, which may be of steadily increasing effectiveness, are less and less accessible, because of their cost, to the populations faced with acute health problems.

  At its 1978 Conference at Alma Ata, WHO defined a "Health care" strategy (primary health care) which seems particularly well suited to the needs. The use of simple diagnostic techniques and a reduced, well-adapted and inexpensive pharmacopoeia makes it possible to protect the "health capital" of a population which can then be helped to take on responsibility for its own health.

  Should we not envisage and formulate a strategy of "fertility care" or "primary fertility techniques" for peasant farmers in Africa with their very low purchasing power and uncertain land resources with a view to achieving the long-term development of fertilizers and the rural sector in Africa?

(The local population is considered responsible for its own health and therefore capable of defining its health objectives, its priorities, its means and its methods and of taking care of itself. This basic health action must be carried on in close relationship with health centres at all levels and of all kinds.)

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Annex 1

CONSUMPTION OF FERTILIZER NUTRIENTS PER HECTARE OF ARABLE LAND AND PERMANENT CROPS, 1983/84

(kilograms)

Country	N	P_2O_5	K_2O	Total
Angola	1.1	1.1	0.2	2.5
Benin	1.7	0.8	0.5	3.0
Botswana	0.4	0.3	0.3	1.0
Burkina Faso	1.5	2.3	1.2	5.0
Burundi	0.7	0.7	0.8	2.1
Cameroon	1.8	0.6	2.3	4.8
Central African Republic	0.7	0.0	0.0	0.7
Chad	0.6	0.5	0.6	1.7
Congo	1.2	0.0	1.2	2.4
Côte d'Ivoire	2.5	1.9	6.3	10.7
Ethiopia	1.3	2.2	0.0	3.5
Gabon	1.3	0.7	3.1	5.1
Gambia	6.9	6.9	1.9	15.6
Ghana	4.0	2.5	1.2	7.7
Guinea	0.3	0.1	0.2	0.6
Guinea-Bissau	1.0	4.2	2.4	7.7
Kenya	13.4	21.3	2.9	37.6
Lesotho	1.7	13.4	0.0	15.1
Liberia	2.4	3.1	1.9	7.5
Madagascar	2.5	1.2	1.0	4.6
Malawi	10.8	4.3	1.4	16.4
Mali	4.2	2.0	1.2	7.5
Mozambique	3.1	3.7	0.9	7.7
Niger	0.4	0.1	0.1	0.5
Nigeria	4.1	3.0	1.6	8.7
Rwanda	0.1	0.1	0.1	0.3
Senegal	1.3	1.9	1.6	4.8
Sierra Leone	0.5	0.4	0.2	1.1
Somalia	1.7	0.3	0.3	2.3
Sudan	6.7	0.1	0.0	6.7
Swaziland	73.5	36.8	33.1	143.4
Tanzania	3.0	0.8	0.4	4.2
Togo	0.8	0.7	0.6	2.1
Uganda	0.0	0.0	0.0	0.0
Zaire	0.6	0.4	0.4	1.4
Zambia	8.5	3.2	1.2	13.0
Zimbabwe	30.3	16.3	11.0	57.6

(Source: 2b.)

Annex 2

PERIURBAN, INTERMEDIATE AND MARGINAL PRIMARY POPULATION

	PERIURBAN (1,000 persons)							INTERMEDIATE (1,000 persons)							MARGINAL (1,000 persons)						
	1950	1960	1970	1980	1990	2000	2010	1950	1960	1970	1980	1990	2000	2010	1950	1960	1970	1980	1990	2000	2010
Côte d'Ivoire	64	120	278	680	1 300	2 340	4 000	1 319	1 614	2 532	3 230	3 800	4 400	3 630	900	930	1 150	1 250	1 100	400	150
Mali	40	62	136	260	480	790	1 200	1 720	2 078	2 474	3 020	3 860	5 090	6 000	1 350	1 650	1 950	2 250	2 150	1 500	800
Upper Volta	24	44	94	209	400	640	960	1 886	2 346	3 406	3 751	4 080	4 360	4 620	1 400	1 600	1 100	1 000	900	850	800
Senegal	82	132	248	472	830	1 380	2 100	1 478	1 628	2 042	2 178	2 030	1 740	1 230	500	600	700	650	600	550	500
Niger	22	34	76	140	260	470	800	1 153	1 434	1 907	2 690	3 680	4 790	5 530	900	1 150	1 500	1 950	1 700	1 150	800
Mauritania	3	6	24	86	166	260	380	425	496	575	589	564	530	410	300	400	450	400	350	300	250
WAEC	235	398	856	1 847	3 436	5 880	9 440	7 981	9 596	13 026	15 458	18 014	20 910	21 420	5 350	6 350	6 850	7 500	6 800	4 750	3 100
Benin	28	50	100	246	486	804	1 240	852	1 080	1 260	1 294	1 214	1 196	890	550	600	650	550	400	150	50
Togo	22	38	82	144	260	440	720	600	677	891	1 203	1 460	1 780	1 730	450	550	550	550	450	200	80
Gambia	4	5	12	36	64	104	156	133	138	173	202	246	316	294	100	150	200	200	150	50	20
WAEC and Observers	289	491	1 050	2 273	4 246	7 228	11 556	9 566	11 491	15 350	18 157	20 934	24 202	24 334	6 450	7 650	8 250	8 800	7 800	5 150	3 250
Nigeria	1 060	2 160	4 280	7 800	13 200	21 600	32 200	21 450	26 490	32 910	37 830	42 680	44 370	42 960	5 600	4 850	3 850	1 700	1 050	650	400
Ghana	118	305	505	940	1 540	2 440	3 760	2 232	3 595	4 195	5 560	6 320	6 550	6 090	1 250	1 300	1 000	700	400	250	150
Guinea	48	90	164	300	500	800	1 240	1 402	1 510	1 836	2 280	3 560	4 480	4 820	1 050	1 100	1 200	1 300	550	250	100
Sierra Leone	30	47	86	164	292	500	800	912	1 164	1 451	2 018	2 418	2 880	3 080	600	550	500	200	150	100	50
Liberia	24	38	61	120	230	420	740	295	410	588	796	1 020	1 200	1 240	300	350	400	400	350	300	250
Guinea-Bissau	13	20	20	32	54	90	148	194	269	329	436	536	660	692	200	250	200	150	100	50	50
Cape Verde	5	8	12	15	20	28	36	75	83	96	103	120	112	104	100	100	100	100	100	100	100
ECOWAS	1 587	3 159	6 178	11 644	20 082	33 106	50 480	36 126	45 012	56 755	67 180	77 588	84 454	83 260	15 550	16 150	14 500	13 350	10 500	6 850	4 350

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PHOSPHATIC FERTILIZER PROBLEMS*

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document is a translation of an unedited original.

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Introduction

It is quite clear that the odds against being able to resolve such a vast problem as this in a short report are very much against us. We can, however, hope to put before our readers some of our thoughts which, we hope, can show them new possibilities and so help them to find a solution to their problems.

It is not possible to envisage any complete separation between phosphate fertilizers and the other forms (N and K_2O) when we take into account the fact that the P_2O_5 component cannot be utilised on its own and that it is in fact only an essential link in the fertilization process. (Certain phosphate-based fertilizers such as DAP and MAP are, however, directly associated with nitrogen.)

It should also be noted that the study is designed to cover highly differentiated situations in the various countries, and that these are difficult to compare one with another. For example we may cite :

- Countries whose phosphatic fertilizers industries are directed either to the international markets or just to the domestic market;
- Countries whose geographical situation, with access to the sea and transport infrastructures, allows the easy entry of imported products or those countries which are land-locked;
- Countries which either enjoy, or lack, a major and solvent domestic market;
- Countries having major resources of raw materials of a quality meeting the standards of the fertilizer industry;
- Countries having raw materials resources of mediocre quality and quantity and which are more or less difficult to extract;
- Countries which subsidize their agriculture through fertlizers;
- Countries with a fully-defined agricultural policy (support for industrial crops, or the development of food crops, etc.);
- Countries possessing a technical environment which is thus able to master an industrial project;
- Countries concerned above all to minimize all forms of inputs;
- Countries with differing cultivation conditions (soils, climate, plants, etc.);
- etc.

It is thus possible to envisage an infinitude of combinations, and this alone illustrates the complexity of the problem to be resolved.

There is no general solution, and every case must be the subject of an individual study.

Deposits of phosphatic minerals are relatively widely distributed in Africa, and one may thus hope to be able to achieve fertilization using phosphates by utilising these resources.

THE PRINCIPAL PHOSPHATIC FERTILIZERS

These are very numerous. We list below the maximum number of such products, indicating with an asterisk (*) those products which are still in an experimental stage.

The products :

These may be grouped into four major families :

1 - Products containing completely attacked phosphates

- Simple superphosphates (H_2SO_4 attack)
- Enriched superphosphates (H_2SO_4 and H_3PO_4 attack)
- Triple superphosphates (H_3PO_4 attack)
- Nitrophosphates (HNO_3 attack)
- Sulpho-nitrophosphates (HNO_3 + H_2SO_4 attack)
- Sulpho-nitro-phosphophosphates (HNO_3 + H_2SO_4 + H_3PO_4 attack)
- Dicalcium phosphate (HCl attack)
- Phosphoric and superphosphoric acids
- Salts of the above acids (DAP, MAP, etc.)
- etc.

2 - Phosphatic products obtained by means of thermal processes

- Alumino-calcium phosphate (Phospal)
- Rhenania phosphate
- Fused phosphates (China, Canada, Brazil)
- Basic slags.

3 - Products containing phosphate rocks

- Fertilizers for "Direct application", containing essentially ground phosphate as the phosphatic product
*- Combinations of ground phosphates and organic materials
- Combinations of ground phosphates and sulphur (Bio-super)
*- Combinations of ground phosphates + sulphur + bacteria (Polish process)
*- Combinations of ground phosphates + micro-organisms (India).

4 - Products containing partially-attacked phosphates

- Attack using phosphoric acid
- Attack using sulphuric acid
- Attack using nitric acid
- Attack using a mixture of the above acids
- Attack using the above acids in the presence of salts
*- Attack using nitrous oxides in the presence of organic materials (Humifert process)
*- Attack using the organic acids resulting from the simultaneous composting of organic materials
*- Attack using SO_3 (Polish process).

It may be seen that the products are very numerous and very diverse, so that the possibilities opened up are also very extensive.

Whilst the products in family 1 are well known, since they form the traditional range of fertilizers, the same does not apply to the other families, and it is necessary therefore to provide at least a minimum of supplementary information.

Products in family 2

- Phospal is a special product obtained by the thermal treatment of an alumino-calcium phosphate mineral from Senegal: P_2O_5 = 30% to 34%. It is an interesting product for fertilizing neutral or alkaline soils.
- Phosphates which have been broken down by the thermal treatment of phosphate minerals in an alkaline environment and in the presence of silica. Their production requires large amounts of energy.
- Fused phosphates obtained by the high-temperature treatment of mixtures of phosphatic minerals and fluxes such as serpentinite. These products can be produced at semi-artisan level, but they do require large amounts of energy. They are very widely used in China (magnesium phosphate). Low grade phosphates can be utilised. These products have neutralising properties. P_2O_5 = 15% to 20%.
- Slags, which are in fact a by-product of the dephosphoration of steel. P_2O_5 = 12% to 18%. The product contains CaO and MgO and hence has neutralising properties; it also contains many trace elements.

Products in family 3

This less widely-used family consists of more specialised products. It is in fact possible to utilise phosphatic minerals directly as fertilizers.

The phosphate contained in this type of fertilizer has not therefore undergone any chemical treatment, and is thus in its original form; it is, however, generally ground.

In this type of product the transfer of the P_2O_5 to the soil and to the plant is very much slower than with the other forms of fertilizers, and a number of precautions must be taken if the result is not to be failure.

The utilisation of this type of fertilizer meets certain constraints :

- The acidity of the soil (pH < 5.5).
- The climatic conditions (rainfall and temperature).
- The efficacy varies with the plant concerned.
- The general need for fine grinding (90% < 63 microns).
- The quality of the phosphate (not all phosphates can be used). Very careful analyses have to be carried out to judge the quality of the phosphate :
  - Its solubility in various reagents (formic and citric acids, etc.);
  - The kinetics of the P_2O_5 extraction in columns;
  - The porosity of the phosphate (Hg or BET absorption);
  - The crystallographic parameters;
  - Mineralogical analyses;
  - Confirmatory agronomic trials (Measurements on the P_2O_5 extracted by the plant).

Once these precautions have been taken it is possible to obtain in this way products which are extremely efficacious and very economical. (The African continent possesses a number of phosphates which may be used : Tunisia, Algeria, Morocco, Senegal (Matam), Mali (Tilemsi), etc.

This type of product has often been criticised on the grounds of low concentration, making transport costly. This comment calls for some correction since these phosphates generally have an improving effect on the often acid soils of Africa, by reason of their contribution of CaO and MgO. A very simple calculation leads to an interesting comparison.

Quantity		P_2O_5	CaO → $CaCO_3$		Total P_2O_5 + $CaCO_3$
1.0 tonnes super triple	=	0.450	0.200	0.400	0.850
1.6 tonnes phosphate	=	0.450	0.720	1.440	1.890

Amount of P_2O_5 + $CaCO_3$ from 1 tonne super triple = 0.850
Amount of P_2O_5 + $CaCO_3$ from 1 tonne phosphate = 1.180

The criteria for selecting the phosphates differ considerably from those normally employed, and make it possible to utilise phosphates normally regarded as of no interest and which are thus cheaper.

The other products in this family reflect the desire to increase the availability of the P_2O_5 in the phosphate by :

- Solubilization taking place in the soil effected by various means such as :
  The natural oxidation of sulphur to produce SO_2 and then SO_3;
  The accelerated oxidation of sulphur by bacteria;
  Direct solubilization using bacteria or moulds.

The authors claim to be able to utilise a wide choice of phosphates (such as indurated phosphates).

Products in family 4

This family also consist of fairly special products which are, in fact, intermediates between direct application products and the conventional products which are regarded as being totally and immediately soluble.

It has already been seen that in the case of the direct application of phosphates one of the factors limiting the use of this technique was the relatively slow rate at which the P_2O_5 was made available to the plant, so that the selection of directly utilisable phosphates had to be rigorous, eliminating a large number of phosphates.

The need was soon felt, therefore, to seek to improve the mobility of the P_2O_5 by partial attack on the phosphate so as to improve :

- The agronomic qualities of the phosphate;
- The range of utilisable phosphates;
- The fields of application (less acid soils).

Here again a number of errors were committed and, contrary to what had been hoped, the products obtained by partial attack were found to be less agronomically effective than the initial phosphate. A technique which, at the start, had seemed simple was in fact found to be much more complicated.

It was very soon seen that it was necessary to maintain total control of the reaction conditions so as to prevent the formation of certain intermediate chemical compounds which appeared during the attack process; once these conditions were fulfilled the technique involved became relatively simple.

(See the Annex relating to partial attack processes.)

It was also found that these products are not just a combination of attacked and non-attacked products, but their properties make them quite individual products, particularly where their agronomic properties are concerned.

Concluding, therefore, it is possible by means of partial attack on phosphates -

- To obtain products which are agronomically interesting because of their :
  - Agronomic efficacy,
  - Improving effect, by supplying Ca and Mg,
  - The 'starter' effect from the attacked part,
  - The long-term release of the P_2O_5,
  - The lower blocking of the P_2O_5 in certain soils,
  - etc.
- To obtain products which are of economic interest because of :
  - Reductions in the quantity of the attacking agent. From 20% to 30% is generally sufficient to obtain effective products (acids are generally expensive),
  - An extension of the range of phosphates which can be used, with the possibility of using phosphates generally regarded as of little interest (reactivity, percentages of R_2O_3 and MgO),
  - A simplification of the processing installations (semi-artisan techniques),
  - etc.

Nevertheless the advisability of implementing this technique is linked with a number of parameters which need to be studied case by case, since the final aim of any operation is to reduce the cost of fertilization rather than the production of a cheap fertilizer.

Commercial forms of fertilizers

The products are marketed in various forms :

- Fine powders, less than 200 microns, as in the case of ground phosphates, not generally liked by users because of the dust;
- Coarse powders, up to 2 mm;
- Semi-granulated, 6-7 mm (Run of Pile);
- Granulated, spherical products either 1.5-4 mm or 2-5 mm, easy to store and to handle, low uptake in bulk, little dust, etc.;
- Compressed or compacted, a less spherical product with a broken appearance, more dusty because of the abrasion of the edges;
- For completeness there are liquids, suspension, slurries, etc., but these forms are not used in Africa.

The normal packaging is in 50 kg woven polypropylene bags with an inner sealed and sewn polyethylene bag. Little use is made of bulk storage.

PRODUCTION PROBLEMS

The basic raw materials

The production of fertilizers requires a limited number of basic raw materials as follows :

- Phosphatic minerals.
- Energy-providing materials (coal, oil, gas, electricity, lignites, etc.).
- Sulphur-containing minerals (metal sulphides, gypsum, sulphur).
- Potassium-containing minerals (sylvinite, carnallite, etc.).
- Magnesium-containing minerals (serpentinite, dolomite, giobertite, etc.).

These products can participate more or less directly in the production of phosphatic fertilizers.

The principal production processes are shown in the following pages, which illustrate the principal combinations which can be envisaged.

The intermediate raw materials

These are the products which are manufactured more or less directly from the basic products and which are major intermediates in the production of fertilizers.

They can be easily bought as raw materials for the converting industries, and are generally manufactured in the major chemical complexes.

They include :

- Sulphuric, phosphoric and nitric acids (it should be noted that because of the concentration needed in fertilizers it is not possible to transport nitric acid);
- Ammonia (a concentrated product containing 82% nitrogen; difficult to transport and to store);
- Urea, ammonium nitrate, DAP, MAP and Super 45, which are also regarded as finished products.

The supplementary raw materials

These are essential in fertilizers, and may be associated with the phosphatic products indicated above. They include :

- Ammonium sulphate,
- Ammonium bicarbonate,
- Potassium nitrate,
- Calcium nitrate,
- Potassium chloride,
- Potassium sulphate,
- Potassium-magnesium sulphate
- Trace elements,
- Magnesium oxide and salts,
- etc.

The basic phosphatic fertilizers must be as compatible as possible with these substances.

The criteria for selecting raw materials

As has already been seen in the previous sections the choice of the raw materials generally depends on their subsequent utilisation. We will attempt to identify the criteria to be adopted for the principal products.

I - The phosphate

This is the fundamental raw material.

I-1 Direct application

- The solubility of the phosphate in formic or citric acids.
- The dynamic solubility.
- The porosity of the phosphate and its specific surface area.
- Certain crystallographic and mineralogical parameters.

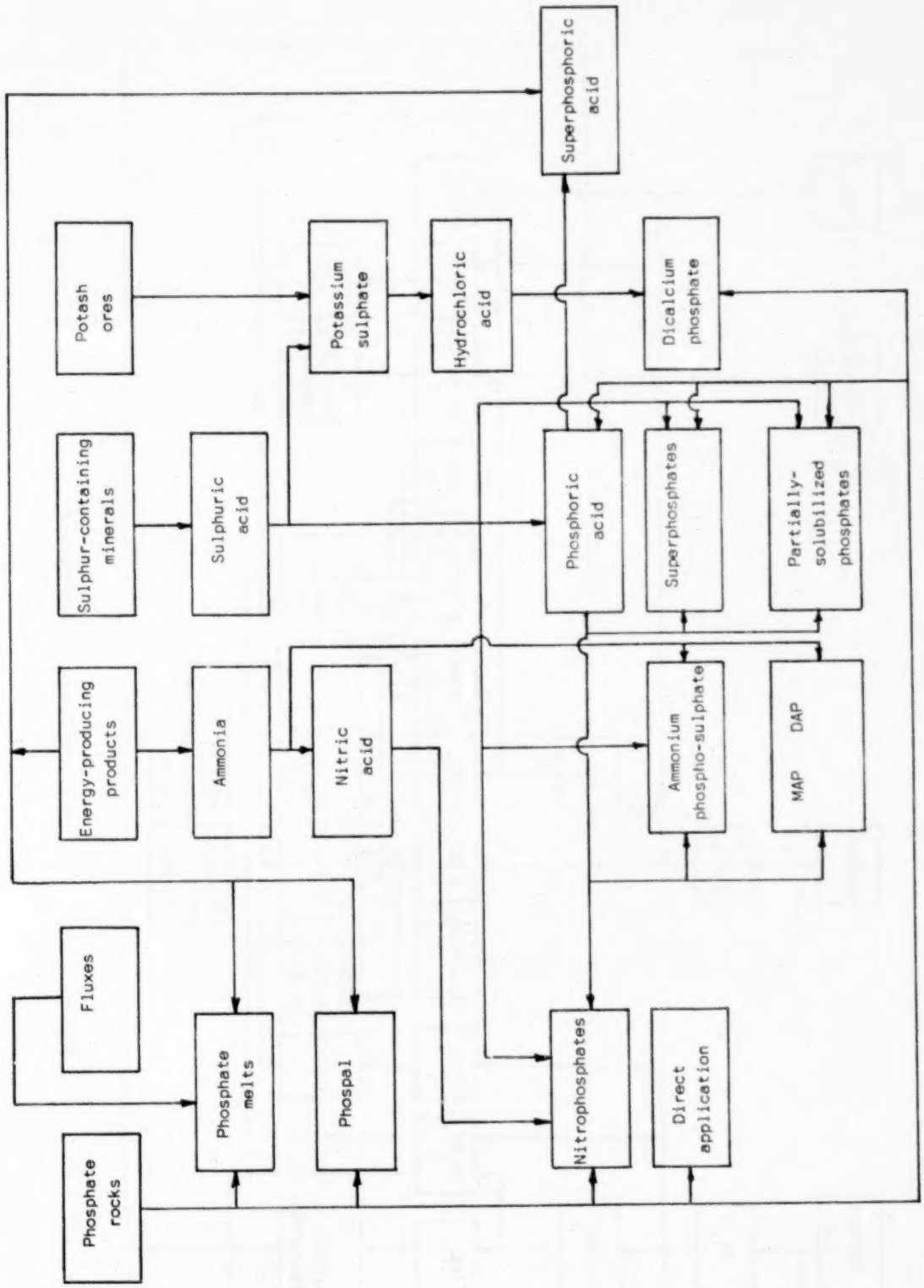

Superphosphoric acid
Potash ores
Potassium sulphate
Hydrochloric acid
Dicalcium phosphate
Sulphur-containing minerals
Sulphuric acid
Phosphoric acid
Superphosphates
Partially-solubilized phosphates
Energy-producing products
Ammonia
Nitric acid
Ammonium phospho-sulphate
MAP DAP
Fluxes
Phosphate melts
Phospal
Nitrophosphates
Direct application
Phosphate rocks

FIGURE 1

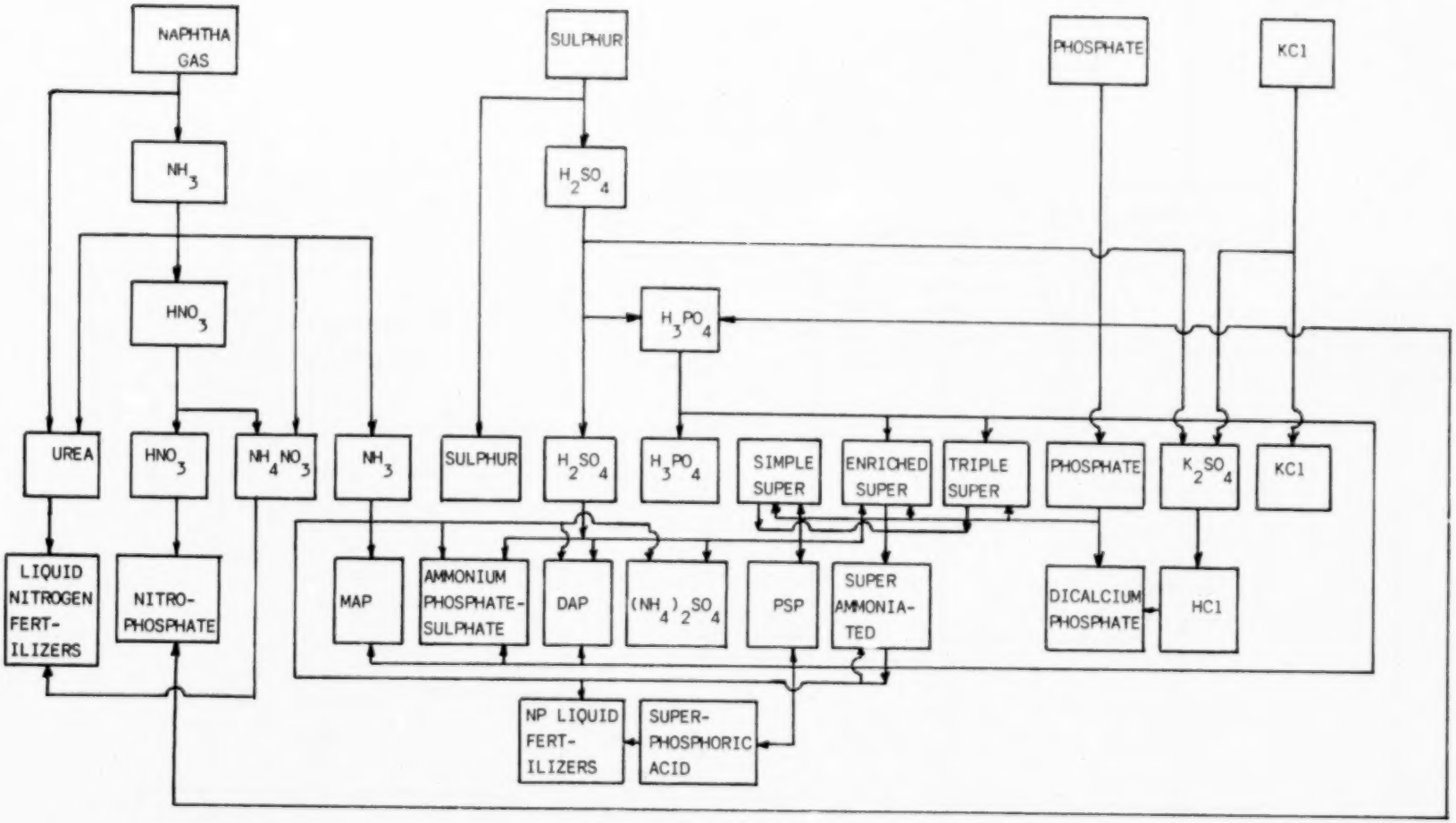


Figure 2 The principal fertilizer routes

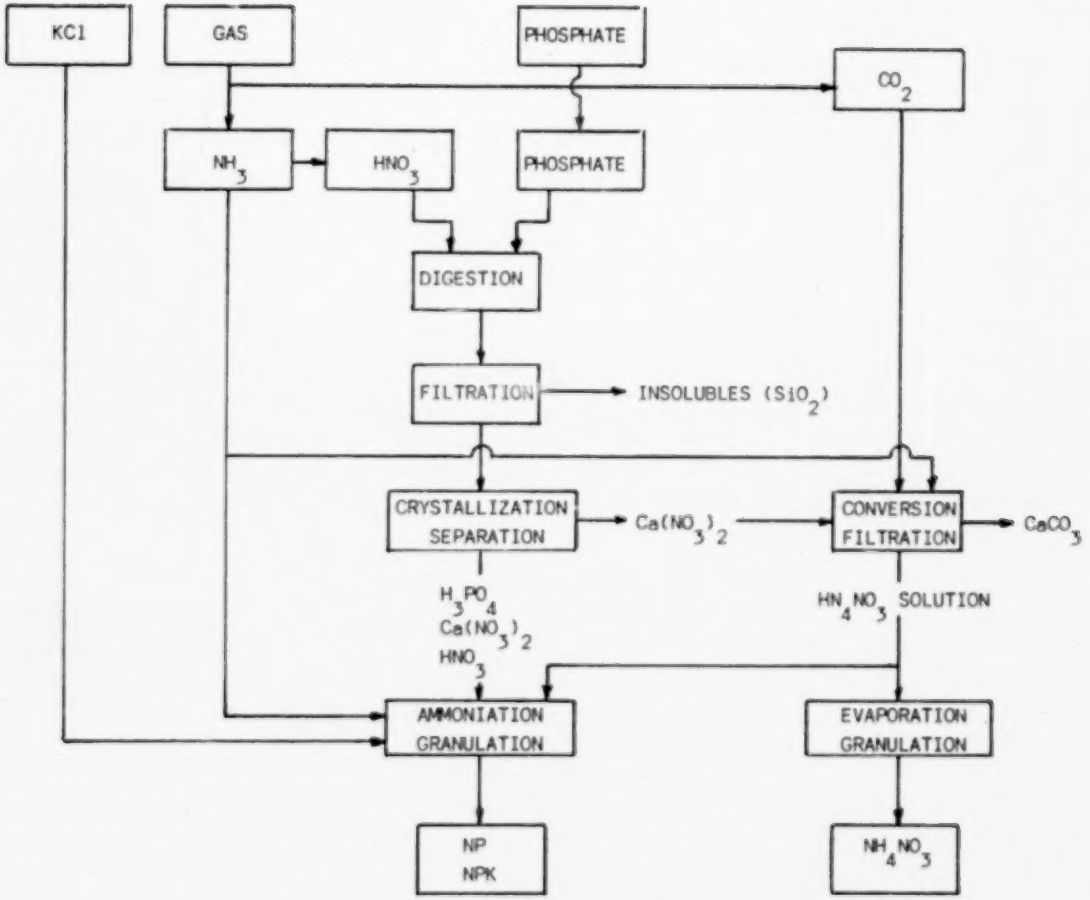


Figure 3 The nitrophosphates

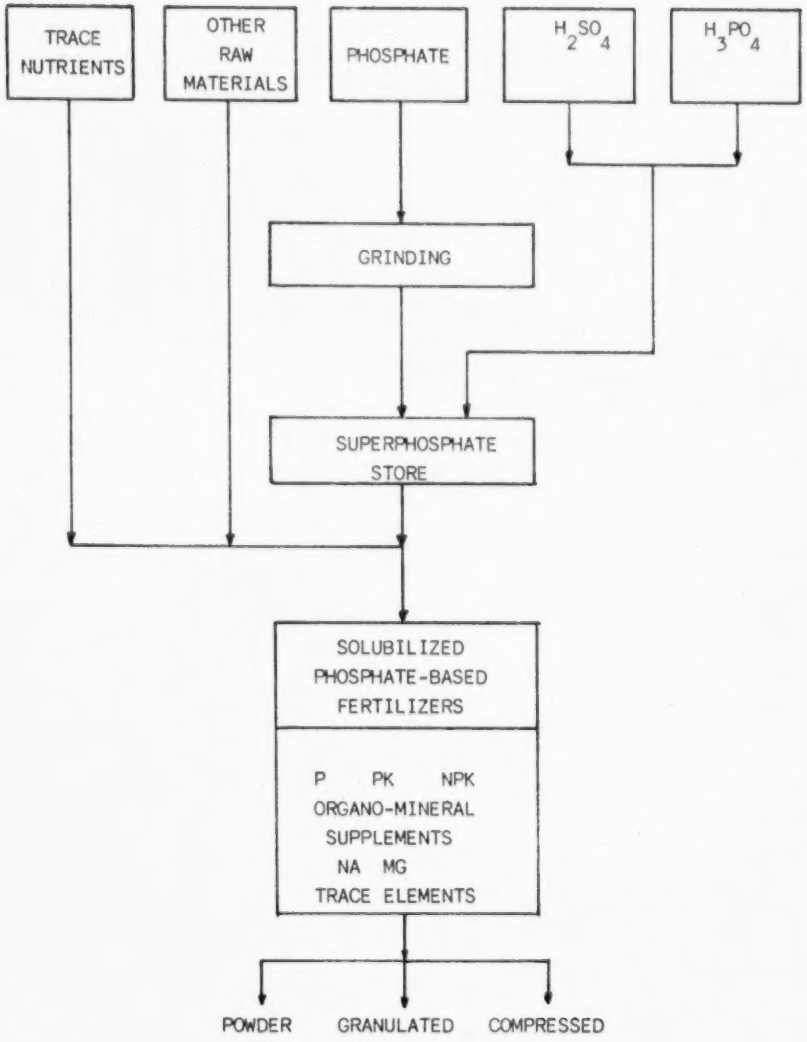


Figure 4 The so-called totally sulubilized phosphate-based fertilizers

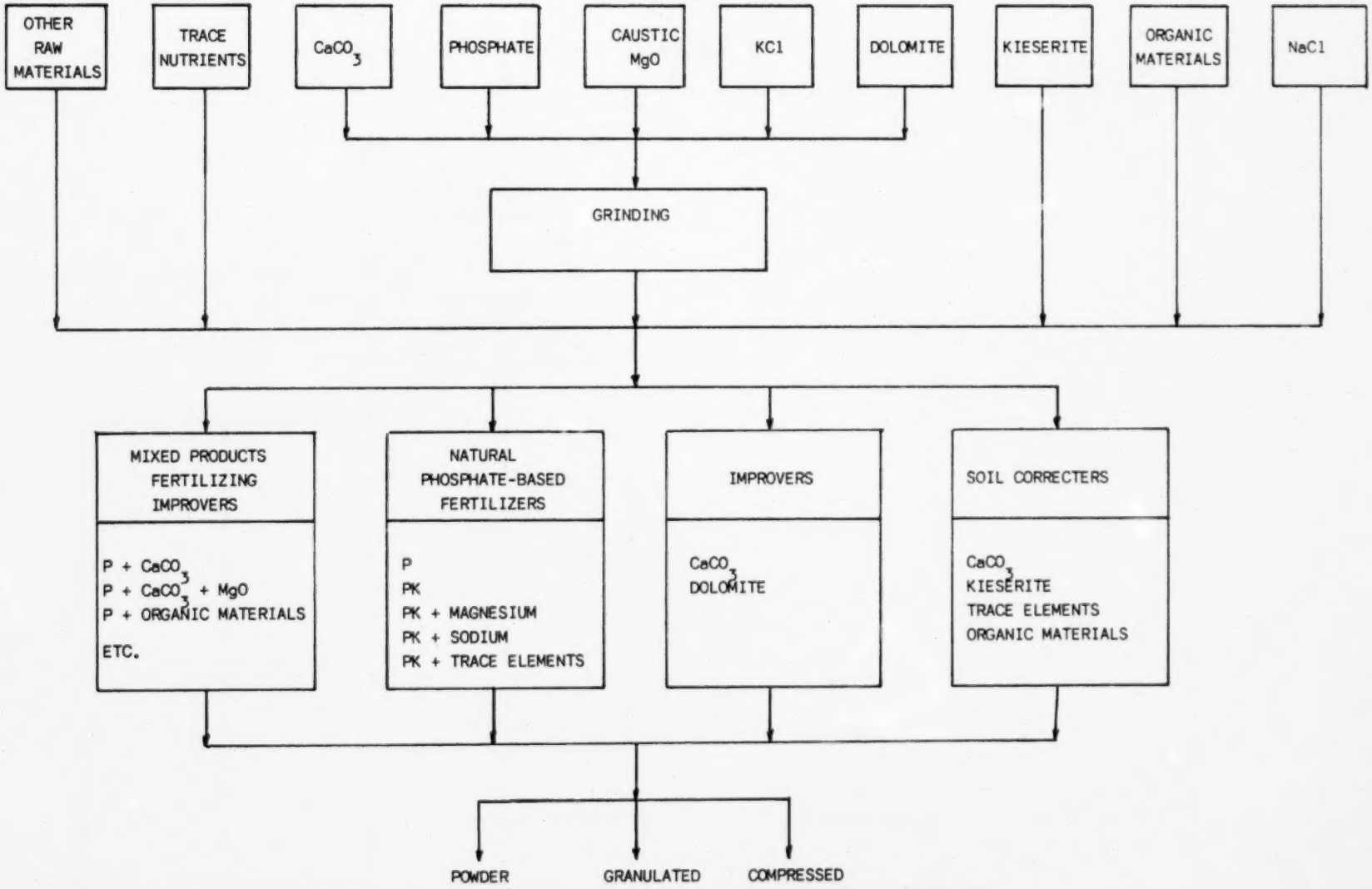


Figure 5 Fertilizers based on natural phosphates

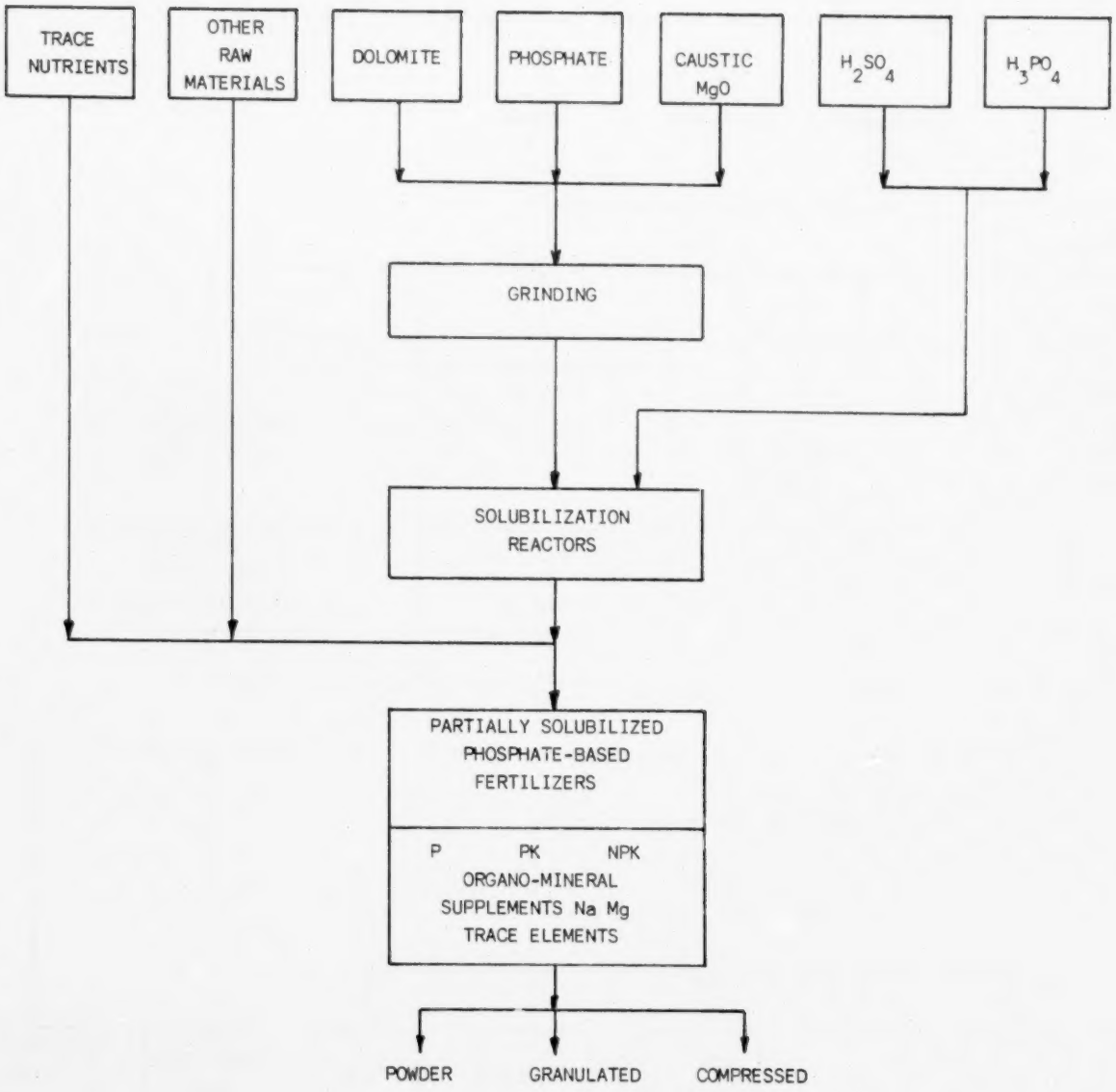


Figure 6 Partially solubilized phosphate-based fertilizers

Fig. 7 : List of the basic or ancillary raw materials used in the production of fertilizers

	N	P_2O_5	K_2O	Na_2O	MgO	S	Trace elmts	Organic matter
Phosphate		x						
Partially solubilised phosphate		x				x		
Simple super		x				x		
Triple super		x						
Alumino-calcium phosphate		x						
Basic slags		x					x	
Dicalcium phosphate		x						
Potassium phosphate		x	x					
MAP	x	x						
DAP	x	x						
Ammonium sulphate	x					x		
Ammonium carbonate	x							
Ammonium nitrate	x							
Ammonium chloride	x							
Potassium nitrate	x		x					
Cyanamide	x							
Urea	x							
Sulphur-containing urea	x					x		
Ammonium sulpho-nitrate	x					x		
Calcium nitrate	x							
NH_3	x							
Sulphomag			x		x	x		
Potassium sulphate			x			x		
Potassium chloride			x					
Lysine production residues	x		x			x		x
Mixed sodium/potassium chloride			x	x				
Sodium chloride				x				
Sodium phosphate		x		x				
Calcium-magnesium phosphate		x			x			
Sulphur						x		
Kieserite					x	x		
Magnesium oxide					x			
Dolomite					x			
Magnesium carbonate					x			
Colemanite							x	
Sodium borate				x			x	
Marl					x		x	
Isobutylene di-urea	x							
Fermentation washes	x		x			x		x
Molasses								x
Ground hoof and horn	x							x
Dried leather offcuts	x							x
Dried agricultural waste	x							x
Poultry droppings	x	x	x		x			x
$CuSO_4$ - Cu_2O							x	
$ZnSO_4$ - ZnO							x	
$MnSO_4$ - MnO etc.							x	

- The P_2O_5 concentration of the phosphate, which is determined solely by the transport problems, and which may be low (15% to 25%).
- If possible a low free silica content so as to avoid major maintenance costs on the grinders.
- The presence of magnesium is, on the contrary, an advantage.

It may be pointed out that if the characteristics of the phosphate meet the utilisation criteria in regard to the mobility of the P_2O_5 then the other constraints are relatively minor, so that it is generally possible to utilise the phosphate directly without enrichment treatment, or at least after limited treatment.

I-2 The production of phosphoric acid

The production problems here are much more complicated, and pose much greater constraints.

- The maximum P_2O_5 concentration is required, with the highest possible P_2O_5/CaO ratio so as to limit the acid usage.
- The minimum Al_2O_3, Fe_2O_3 and MgO percentages, to reduce the consumption of acid and to reduce the formation of troublesome compounds.
- The minimum chlorides percentage and SiO_2/F ratio so as to limit corrosion.
- The minimum organic materials percentage to prevent foam formation and to limit the usage of anti-foaming additives.
- The minimum cadmium percentage (international legislation).
- The minimum free silica, to limit abrasion.
- The reactivity of the phosphates, to limit -
  - capital investments in grinding and the reaction vessel,
  - the consumption of energy during grinding and for stirring in the reaction vessel.
- The crystal form of the gypsum (filtration).
- etc.

Enrichment and purification treatments of the phosphatic mineral, which are sometimes very costly, are therefore generally necessary.

The constraints are thus considerable and limit the grades of phosphate which are economically utilisable.

In the production of phosphoric acid it is of interest to examine the following parameters, all related to the production of 1 tonne of P_2O_5 as phosphoric acid -

- The quantity of phosphate needed.
- The quantity of sulphur needed.
- The quantity of anti-foams needed.
- The quantity of energy.
- The cost of maintenance caused by corrosion and abrasion.

These items account for a large part of the cost price of the phosphoric acid.

I-3 Nitrophosphates

The constraints here are somewhat less serious than those indicated above, but the following can be cited -

- Maximum P_2O_5/CaO ratio to limit acid consumption.
- Carbonate content not too high, and
- Minimum organic materials percentage, both to reduce foaming problems.

By contrast the level of capital investments and the complexity of the processes is greater.

I-4 Superphosphates

The constraints here are similar to those applying to phosphoric acid, with however slightly more latitude.

- Greater tolerances in regard to the Al_2O_3, Fe_2O_3 and MgO levels.
- Carbonate content of value (expansion of the superphosphate).
- The phosphate being generally ground to a finer size means that its hardness and the free silica content has to be watched more closely.

I-5 Partial attacks

In the special case of partial attack the constraints on the use of the phosphate are generally very minor, since -

- the levels of attack on the phosphate are obviously lower than in the case of total solubilization, so that troublesome reactions can be better controlled,
- the treatments used can be adapted to suit the grade of phosphate being used.

It is possible to use directly those grades of phosphate which are classified as non-usable because of their concentrations of P_2O_5, Al_2O_3, Fe_2O_3 and MgO, and without any enrichment treatment.

Under these conditions the range of acceptable phosphates is very large. In fact the problem which is posed is :

How to treat the available phosphate ?

II - The phosphoric acid

This product is an important intermediate in the manufacture of fertilizers and is often involved as a raw material in the production of many phosphatic compounds.

The quality criteria are :

- A P_2O_5 content exceeding 50%.
- The level of materials in suspension, to limit deposition and losses during storage and handling.
- The minimal reprecipitation of salts, to limit deposits and scaling.
- The minimum percentage of salts in solution. Since this product is used as an acid reaction agent the maximum amount of the P_2O_5 present should be in the form of phosphoric acid.

This product is costly to transport and to store, since it requires special equipment, whilst losses have to be expected during the storage and transport operations.

III - DAP, MAP and Superphosphates

These products, which are widely available on the international market, are the subject of intense competition between the different producers, and are hence not very remunerative. This is why the nitrogen content of MAP and DAP is generally of little interest.

These products do however have the advantage of being very concentrated in respect of their fertilizing units, and so can accept the cost of transport over longer distances.

THE PRODUCTION STRATEGIES

One can distinguish between three production strategies :

1 - A strategy based on the production of fertilizers intended for bulk export, such as :

- More or less enriched phosphatic minerals.
- Phosphoric acid.
- MAP and DAP.
- Triple superphosphate.
- NP and NPK fertilizers, as concentrated as possible.

This strategy demands a high level of industrialization in order to produce, in large quantities, a limited range of standardized products. This strategy is suited to the major producers located at major phosphatic minerals sites. (Production of basic phosphatic fertilizers.)

2 - An intermediate strategy based on supplying nearby markets, national and neighbouring: this is suited to producers of medium size. Here the range of finished products is necessarily wider in order to meet the local conditions. The operating conditions here are much more difficult to control and to optimise.

The major problem in this strategy relates to the possibilities of obtaining raw materials at a good price, since any scale economies do not operate in this case.

3 - A national strategy, based on identifying an economic system of fertilization which is more lightweight, more rustic and nearer to the final user, the peasant farmer.

It needs to be capable of utilising to the maximum the local resources, even if these are modest, supplemented by the generally available raw materials which can be obtained at good prices on the international markets.

Adaptability and flexibility should be its principal advantages.

The choice of the production strategy is the essential starting point for consideration of the implementation of any phosphatic fertilizers production project.

OPERATIONAL CONSIDERATIONS

As can be seen from the simplified scheme for the production of the principal phosphatic fertilizers the production of these in the traditional system involves a number of production units which are integrated vertically, leading to some complexity in operation.

These units are not only interdependent in regard to their products but also in regard to energy transfers.

Furthermore these production units can only operate continuously; any shutdowns must be for technical reasons and for limited periods of time, since starting up again is very costly in terms of energy and maintenance (reheating of the circuits, slow operation, corrosion on shutting down, etc.).

This leads to some rigidity in the process.

The important points to be taken into consideration are :

- The technical nature of the production units, demanding operators who are not only competent but also very painstaking and highly motivated (constantly seeking the optimal operational possibilities of the unit).

- The high level of capital investments (considerable scale economies, high levels of instrumentation of the units so as to be able constantly to optimize productivity and to achieve a high level of operational safety).

- The need for rigorous management of energy, demanding as a consequence the highest level of utilisation in the units.

Energy recovery takes place by successive stages. A reduction in the level of utilisation in one unit of a few percentage points can therefore have catastrophic results on the final energy balance sheet.

- Optimization of the performance of a unit is rarely achieved at start up. It is normal for it to be reached after several years of work on development and improvement. Perfecting the units must be the constant concern of the operator.

- Since the techniques evolve very rapidly they must be constantly followed up and, if necessary, adapted to the production unit (development budget).

- Management of production is very difficult and requires the steady flow of the products manufactured if one does not want to have to maintain large stocks or to have to shut down the production line sections.

- Management and maintenance must both be above criticism, establishing a good balance between preventive maintenance and breakdown operations; this is not easy to achieve if an industrial fabric does not already exist in the environment of the plant (problems with spares and exceptional support in the case of serious breakdowns).

- The search for simple technical solutions is a primary concern under these conditions. At the time of making the capital investments priority must be given to robust and, in the final resort, artisan-standard installations.

- The skills of the operators and supervisors in charge of the continuous processes must be reasonably high, since they are responsible, for 24 hours every day, for sophisticated and expensive units. They must therefore be able to withstand a fairly stressful situation because of the heavy responsibilities which they have to assume and the work load (shift work).

- Local recruitment of such personnel is not easy, so it is often necessary to call on expatriates, so considerably increasing the wage bill. A policy of training must be implemented.

- It is therefore necessary to have concern for the simplicity of operation.

THE PROBLEMS OF THE TRADITIONAL INDUSTRY

The commissioning of fertilizer production units intended for bulk export, or even to serve neighbouring markets (Strategies 1 and 2) is a very difficult operation to carry out.

It should only be envisaged if an exceptionally favourable series of circumstances can be established.

Competition is pitiless, and it is essential to be able to compete on equal terms with the competitors, making it essential to reach at least an industrialized level of performance.

It is necessary also to remember that the competitors often price their products on the basis of policies which sometimes have nothing in common with the normal criteria of profitability, operating dumping prices for a variety of reasons :

- The desire to ensure control of the markets in the longer or shorter term.
- The need to acquire foreign currency at any price.
- The need to discover markets so as to ensure an acceptable level of utilisation of their units (marginal tonnages).
- The protection of privileged markets.
- The need to reduce stocks,
- etc.

Before launching out into this type of operation it is necessary to examine carefully :

- those projects which are under study or in course of construction,
- any projects involving reconversion and restructuring.

It is also advisable to examine carefully, and in advance, those advantages which are already possessed and which would make it possible to withstand such a situation.

The important parameters to be taken into account are :

- Significant resources of good quality phosphate which can be easily mined.
- Energy resources (gas, oil, coal and electricity) available in quantity and supplying cheap energy.
- Resources of sulphur-containing products which could be used to manufacture sulphuric acid.
- A minimum level of control of the market for the finished products or of supplies of raw materials, linked for example with the influence one has on the world market, a particularly favourable geographical situation or privileged agreements.

- The total mastery of the production operations and the maintenance of the units, ensuring an advantageous cost price for the products.

In conclusion :

It seems to us to be particularly hazardous to envisage an operation of international scope unless one can master at least three of the parameters indicated above.

(The examples of such operations undertaken recently show us quite clearly the magnitude of the risks involved.)

The world fertilizer industry is at the present time in a state of major crisis; this is the more serious since it does not result from an excess of capacity over the needs of the consumers but because the price of these fertilizers, as delivered to the fields, cannot be afforded by the potential customers.

Nor must it be forgotten that a profound imbalance exists in the world with agricultural production largely in excess in many countries where it is, at the same time, highly subsidized.

This situation could change rapidly, and this could be catastrophic for a number of Developing Countries which have not promoted their own agricultural development.

Many serious questions must therefore be confronted.

The cost of using fertilizers must be reduced for the user.

Since this in-depth questioning is necessary we must go right to the roots of the problem and ask ourselves a number of questions :

- Is it possible to reduce the price of the traditional fertilizers, and if so, how ?
- Are these products totally suited to crop-growing conditions in Africa, and can they be recommended in all cases ?
- Without denying the need to use traditional fertilizers or their efficacy are there no alternative products which are of greater interest and more economically valid in certain situations ?
- What is the real cost of using fertilizers if one integrates the cost of the treatments necessary to maintain good fertility in the soil and to achieve an increase in agricultural production ?
- Are the logistics and distribution really suitable, or could not both of them be improved ?
- Is it not possible to favour a local mini-industry which would be capable of satisfying the real local needs, and which could perform a number of simple operations such as :
  - Formulating fertilizers;
  - Bagging them;
  - Utilizing local resources of raw materials,

and which would simply operate as a converter, using those widely distributed products from the major producers, and which are therefore available at interesting prices ? (Thus exploiting the incoherences of the world market.)

- Could not the system envisaged have as its ultimate aim that of being supplementary to the traditional system ?

CONSIDERATIONS RELATING TO A NATIONAL SYSTEM

As might be expected the approach needs to be totally different and requires the identification of original solutions.

Since the final aim is to provide fertilizers at the most economical price to the user action must be taken at every stage of the fertilizers circuit.

To this end the following operations must be carried out :

- Produce an accurate inventory of local resources of raw materials which could be used (grades, quantities, location, accessibility and estimates of production costs).
- Produce an accurate inventory of the real needs of the user under real crop-growing conditions (plants, soils and the climate), not only for the fertilizers but also for other products such as soil improvers, pesticides and trace elements.
- Produce an inventory of existing uses of these same products (grades of products used, quantities, timetable of use, precise location of the areas of use, etc.).
- Produce an inventory of fertilizing products which could be supplied economically.
- Produce a complete inventory of the logistic cost along the entire supply and distribution network so as to identify bottlenecks and anomalies (bulk transport and handling of fertilizers i relatively difficult to achieve in Africa, and the costs are very high).
  In our opinion there is a major logistics problem, disrupting not only the distribution of fertilizers but also the collection of finished agricultural produce (means of transport, infrastructures, etc.).
- Determine objectively the real resources of the user in order to fix an acceptable price ceiling for fertilizers.
- Decide how the farmer is to be aided (subsidies on fertilizers or products, introduction of new cash crops, assistance in the purchasing of fertilizers, etc.).
- Determine which structures are to be responsible for this development at country and user levels.
- Determine which products could be produced economically.
- Determine which system would allow the creation of value added at a high local level, in this way limiting inputs and saving currency.

- Determine the technical means to be implemented to manufacture these products economically, limiting the capital investments required and hence also the risks (this could involve the revamping of a unit).
- Identify the entrepreneur to be responsible for the complete management of the project. This point seems to us to be particularly important, since in our opinion nothing of value could be achieved without a competent and responsible coordinator and driving force: the ongoing work of optimising costs at each stage will be a necessity for the success of such a project. He must have all the necessary powers.
- Define a coherent and clearly set-out national policy for the use of fertilizers (draconian control of imports, clear definition of the utilization of additives in fertilizers, etc.).
- Seek cooperation between countries to share resources (port facilities, shared storage of raw materials, logistic resources, customized production, etc.).

As may be seen this is very far from a purely technical approach. The intervention of a large and multi-disciplinary team is necessary, and within this team the final user must be strongly represented. His real problems must form the starting point for all considerations on the subject.

This approach, which would seem to be logical, is not unfortunately always followed. One can see the construction of national projects which are limited to the building of "shop-window" factories, overlooking the fact that production cannot exist unless one can sell the products which are being manufactured.

All this seems to be complicated, but studies carried out in a number of countries have shown us that the cost of fertilizer usage could be reduced if these parameters were examined with care and, above all, together.

We have been able to ascertain that :

- The logistic cost is generally much greater than the production cost.
- The road infrastructure often does not permit the normal flow of products. (This is a very important point, since the costs resulting from rectification of the situation cannot be met by any one fertilizer project.)
- The economies achieved by a good choice or good purchasing of raw materials is sometimes even greater than the production cost.
- Independence in buying is absolutely essential. (Flexibility in the use of raw materials.)
- The farmer recognizes the efficacy of his fertilizers, but he is also sensitive to the appearance of the product; he is mistrustful of powdered products which look too much like 'sand'.

Mistakes must not therefore be made in regard to these priority points.

Unfortunately we have been able to identify, in the course of these same studies, a number of serious anomalies :

- Unsuitable formulae with, as a consequence, wasted fertilizers, such as the use of sophisticated fertilizers intended for cotton being used on cereals, the addition of K_2O to soils sufficiently provided with this element, etc.

- Aberrant logistical costs (ad hoc transport, failure to utilize the potential for return loads, loss of products during transport, etc.).

- Excessively high storage costs (loss of products, long storage times linked with uncertainties regarding supplies, etc.).
- Lack of storage capacity and storage under precarious conditions, making it necessary to buy products at unfavourable times).
- Shortages of supplies at the point of use (favourable climatic conditions creating unexpected demands for fertilizers which cannot be met).
- Or, on the contrary, returns to stock result in product losses (deterioration of the products from one campaign to the next).

The problem is that there is often no management at all, hence losses are considerable throughout the entire length of the network.

An overall approach is neccessary.

By way of illustrating this point Figure 8 on the following page makes it easy to appreciate the need for this type of recommendation, showing the importance of simplifying the circuits and the relative weights of the various operations.

SIMPLIFIED SCHEME FOR STUDYING A LOCAL PRODUCTION PROJECT

This approach to the problem is thus very different from the traditional approach, since it must be defined from the starting point of optimising the following points which are, in reality, interlinked and hence are redundant :

1 - The real cultivation needs as determined by agronomists.
Requirements for fertilizing components :
N, P_2O_5, K_2O, CaO, MgO, S, trace elements.
Ceiling prices for fertilizers.
Timetable of usage, etc.

2 - Local resources of raw materials for fertilizers as determined by geologists, mineralogists and miners.

3 - Possibilities of obtaining supplies of supplementary raw materials at the lowest cost, as determined by specialist buyers.

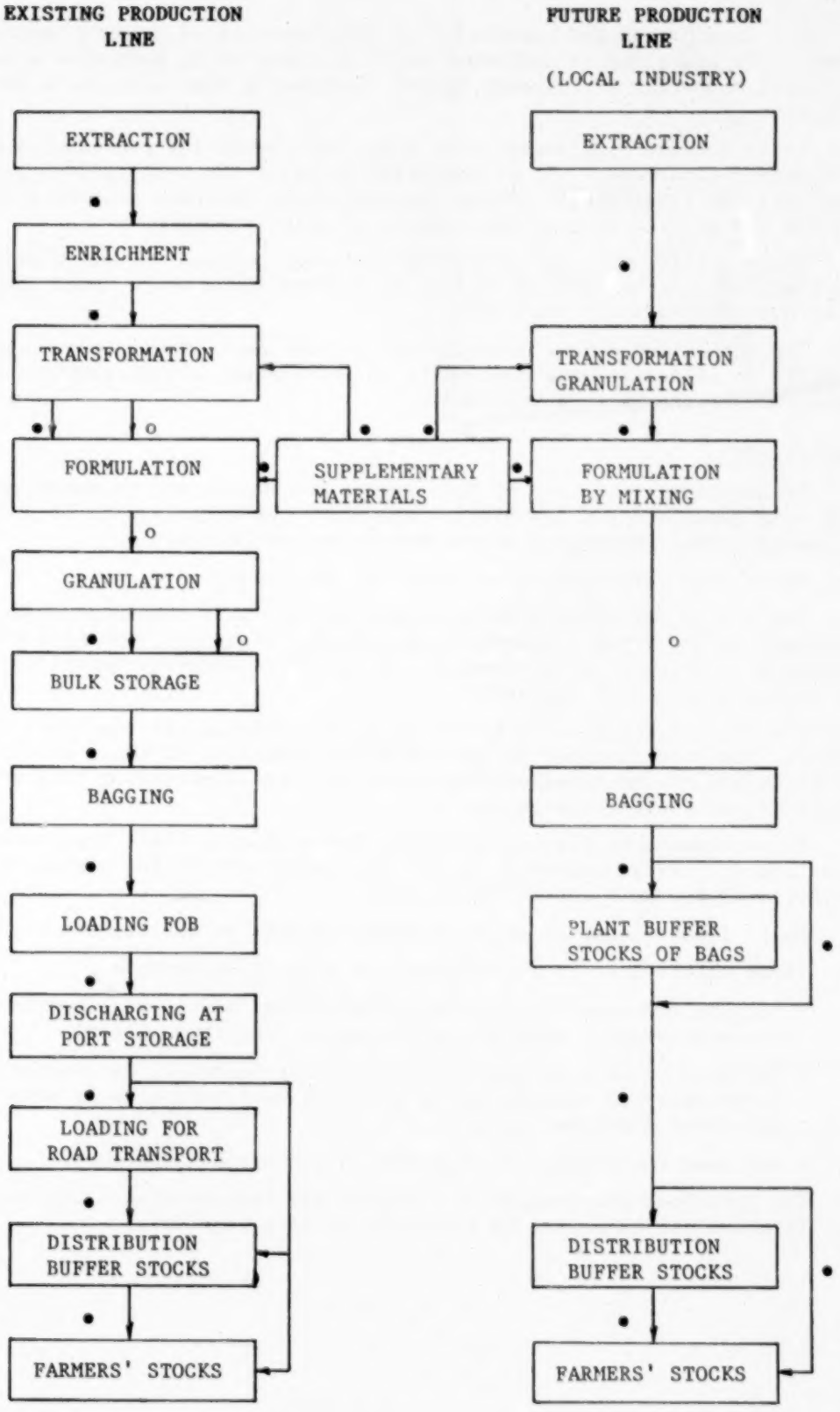
4 - Studies on logistic and distribution costs, carried out by a logistician.

5 - Determination of the products which can be manufactured and of suitable production techniques, carried out by specialists in the production of fertilizers.

6 - Financial and accounting studies (financing of investments, stocks, establishing forecast cost prices, elasticity tests, studies on levels of independence, etc.).

7 - Macro-economic studies to establish a policy for fertilizer usage to be implemented in the country, carried out by an economist.

One sees here again the concept of team work involving persons with multiple competences and viewpoints, integrated into an optimization unit which must be motivated by an entrepreneur who is completely objective and free from any constraints.



- • Load breakdown or transport operation
- o No load breakdown or transport

The imagination and creativity of this team are of primary importance, since it is necessary to implement new techniques or to harmonize a number of techniques which are already known, integrating them all into a coherent system.

It is necessary to accept some risk, this being the consequence of the necessary innovations. It is essential to leave the well-trodden paths; every day the traditional systems demonstrate to us their impotence in solving the problem without the support of major subsidies.

These studies must be carried out for each project and are always specific; however a 'package' could be defined which would speed the work up by systematizing the studies.

The simplified scheme which is set out on the following page makes it possible to illustrate the complexity of the system, linked with the interdependence of the factors involved.

CONCLUSIONS

On arriving at the end of this report the reader may be surprised to find only questions and few precise answers. Nevertheless it is possible to identify some underlying ideas, summarized as follows :

1 - There will certainly be no universal solutions.

2 - The use of fertilizers being essential they must therefore be made available to the farmer, since the development of agriculture is a vital necessity. We have now arrived at a point where the very fertility of the soils is placed in jeopardy.

3 - The cost of fertilizers is too high, considering the resources of the farmer; the known methods do not allow any reduction in their cost (with the situation of the manufacturers being far from flourishing they are more likely to seek price increases).

4 - The economies of African countries force them to limit inputs because of a lack of foreign currency, itself the result of falling prices for agricultural products and raw materials.

5 - Major innovations, or at least major changes in habits, are essential.

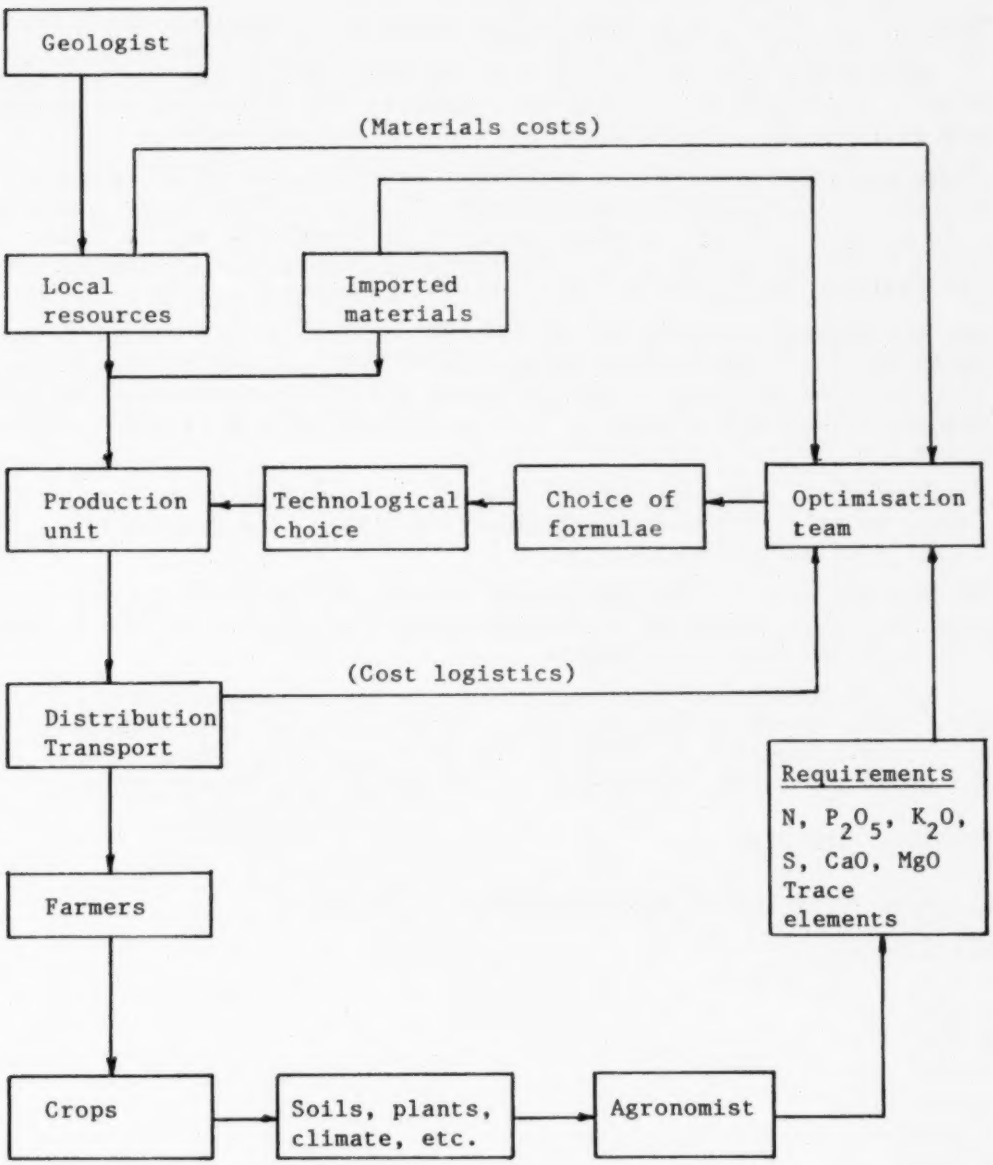
6 - Three points are, in our opinion, of primary importance :

- Firstly the need to structure agricultural development (agricultural cooperatives ?), and to find 'managers' for this policy:
- The need to form an operational unit for technical development (committees of experts and savants) to work very closely with the structure described above:
- The need for states to cooperate in concerted operations.

7 - The technical problems do not present any insurmountable difficulties: what is above all essential is to remain totally realistic.

Simplified scheme for studying a fertilizer project

This deliberately simplified layout illustrates this method for approaching the problems.



ANNEX

PARTIAL ATTACK PROCESSES

INTRODUCTION

Processes for the complete attack of phosphates have been well known for many years: they result in obtaining phosphatic compounds which are more or less soluble and which generally pass rapidly into solution in the soil. These forms are universally used, irrespective of the characteristics of the soil. (Phosphoric acid is not generally used directly, but rather in the form of its salts such as mono- and di-ammonium phosphates.)

These processes require the employment of techniques which, although not of themselves too complicated, are nevertheless difficult and costly to use. As we have seen in the main part of this report the use of these techniques leads to constraints on the chemical composition of the phosphate used, so limiting the number of types of phosphate which can be utilized.

Our experience has shown us that it was possible to use simple techniques to produce partially solubilized phosphates which, contrary to what might have been expected on first principles, were not a juxtaposition of solubilized and non-solubilized phases but rather products having rather unexpected properties.

These products are much more economical to manufacture and are, at the very least, as effective as those products resulting from total attack, if not in fact more effective.

Furthermore some of the constraints imposed on the phosphates used disappear, making it possible to use phosphates regarded as unusable when using the other customary techniques.

Whilst the techniques involved are simple the actual processes of attack call for fairly extensive studies in the laboratory, followed by agronomic trials designed to validate the efficacy of the products when they are used under the normal conditions of use (soils, plants and crops).

THE TECHNIQUES EMPLOYED

The following basic characteristics need to be known :

Chemical analysis -

- % P_2O_5
- % CaO
- % MgO
- % Na_2O
- % K_2O
- % Al_2O_3
- % Fe_2O_3
- % SiO_2
- % F^-
- % Cl^-
- % SO_3
- % CO_2
- % organic matter

Physical analysis -

Particle size distribution
Mineralogical characteristics
Porosity (specific surface area)

Miscellaneous -

Geological origin
Homogeneity of the product
Suitability for grinding

Tests for determining the treatment needed :

Laboratory

Systematic tests are to be carried out in the laboratory on attack by sulphuric and phosphoric acid and on mixed attacks. These involve -

The production on a laboratory scale of samples of products with various levels of attack and various conditions of attack (fineness of grinding of the phosphate, concentrations of the acids, etc.).

Studies on changes in the products with time (2, 8 and 24 days).

Tests on the mobility of the forms of P_2O_5 obtained (dynamics of extraction, solubilization curves).

Determination of the economic attack zones.

Analysis of the test products.

Analysis of the components (spectrometric analysis, etc.).

Pilot-scale plant

The production under semi-industrial conditions of samples intended for the agronomic trials.

Production of products in the following forms -
- Powders
- Run of Pile
- Granulated
- Compressed.

Tests on quality -
- Hardness and strength of the products
- Splitting
- Caking
- Compatibility with other fertilizing materials.

Optimization of the products -
- Quality
- Cost price
- Improvements in the mobility of the phosphatic forms.

Determination of the industrial parameters.

Selection of the technology to be utilized.

Agronomic tests

All the tests and trials carried out only lead to presumptions as to the agronomic efficacy of the products. These must now be verified by trials under glass and in the fields.

In fact experience makes it possible to limit the risks considerably, but modifications in detail can still be carried out to improve the results.

CONCLUSION

The totality of these tests may appear to be onerous, but the potential economies are very considerable (obtaining the product which is agronomically most efficacious at the minimum cost).

DESCRIPTION OF THE PROCESSES

There are two types of processes :

- Batch processes
- Continuous processes.

The choice between these processes is a function of :

- The quality of the phosphates to be processed, some treatments calling for successive attacks:
- The hourly quantity to be processed:
- The quality of the final products (P, PK, NPK):
- The physical form of the final product :
  - Powder
  - Granular
  - Compressed
- The desire or necessity to obtain a product directly granulated.
- etc.

It is necessary to distinguish between the following steps, which are found in all the possibilities :

- The grinding of the phosphate, the fineness being a function of the reactivity of the initial phosphate.
- The quantity of ground product used (with or without one or more other products).
- The preparation of the attack reagent (dilution and metering of the acids, mixing and metering of other solid or liquid products, the metering and addition of surfactants, bringing up to temperature, etc.).
- The first reaction stage (mixer).
- Maturation and possible granulation stage.
- Ripening stage (storage).
- Gas treatment stage.

The following stages are found in a conventional plant producing superphosphate :

- Grinding the phosphate.
- Diluting the acids.
- Metering the phosphate and the acid.
- Mixing before the holding tank.

- Superphosphate holding tank.
- Ripening store.

Moreover in the case of phosphates of standard qualities, or near the standard qualities, the technique for the manufacture of partially solubilized phosphates will be very similar to that of the superphosphates (control of the mixers).

THE ADVANTAGES OF PARTIAL SOLUBILIZATION

As from the time that agronomically efficacious products are obtained the following advantages have to be taken into account :

- Lower cost of the raw materials :
  - Use of phosphates of mediocre quality, local or imported;
  - Reductions in the usage of expensive products which are relatively difficult to manufacture (sulphuric and phosphoric acids);
  - In the case of sulphuric acid lower deconcentration of the products obtained.

  (The cost per unit of P_2O_5 obtained being sometimes only half that of the superphosphate which would be produced locally it may be seen, in the case of certain phosphates, that the quantity of soluble P_2O_5 obtained per unit of acid utilised is greater in the case of partial attacks than with total attacks.)
- A relatively simple operational technique which requires :
  - Lower capital investments;
  - A less sophisticated technological environment (semi-artisan type techniques can be used).
- The products obtained take into account the local cultivation conditions, so giving better results than the traditional products.
- The products can be granulated more easily.
- The products have greater compatibility with other fertilizers such as urea. (Use in bulk blending.)
- The total energy consumption is lower.

It is very difficult to give figures which are generally accurate: a calculation must be made for each case in order to take into account the characteristics of the raw materials which are available, the logistics cost, the level of production which is envisaged, the final products which are required, etc.

THE PROCESS

Three principal phases need to be distinguished :

A - The phase of preparing the products before attack, consisting of :

A1 - Preparation of the liquid products (metering, mixing, reheating, dilution, dissolving the added solid products, etc.).

A2 - Preparation of the solid products (metering, mixing, grinding, etc.).

B - The phase of reaction between the prepared products.
The reaction may be carried out on a batch or continuous basis, and in both cases in successive stages, involving one or more stages of maturation of the products or even a drying operation.

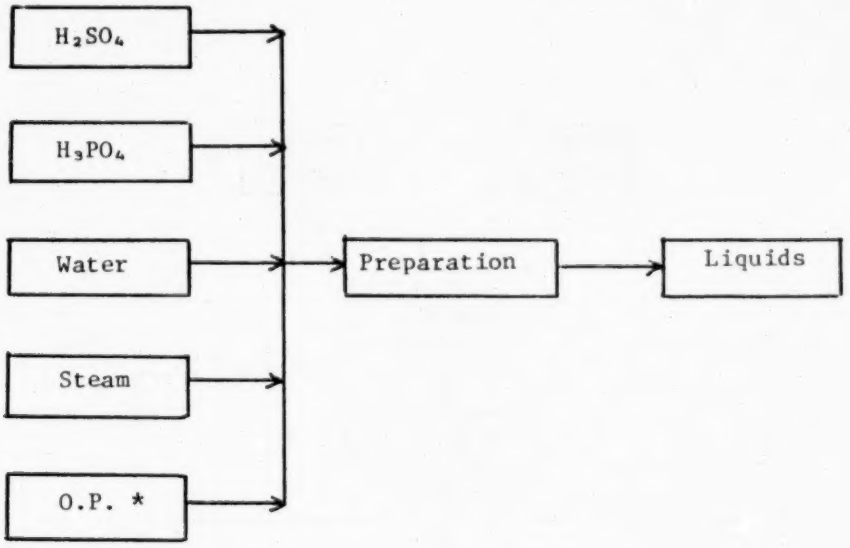
C - The phase of finishing the final product in order to obtain a product in one of the following forms :

- Powder
- Run-of-pile
- Granules
- Compressed.

Phases B and C can in some cases be carried out simultaneously (eg granulation during the attack phase).

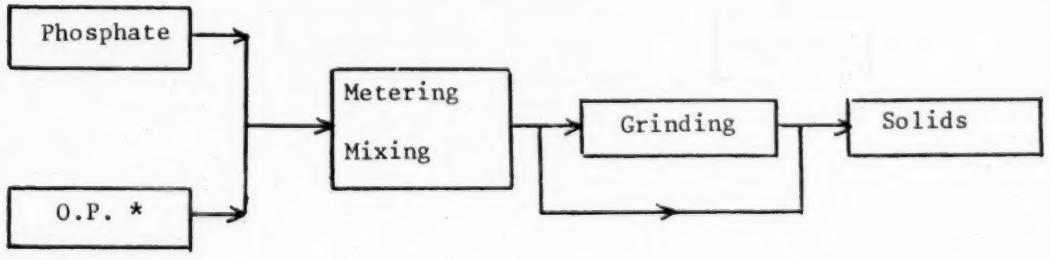
The various operations in these stages are shown in the figures and layouts on the following pages.

PHASE OF PREPARATION OF THE LIQUID PRODUCTS



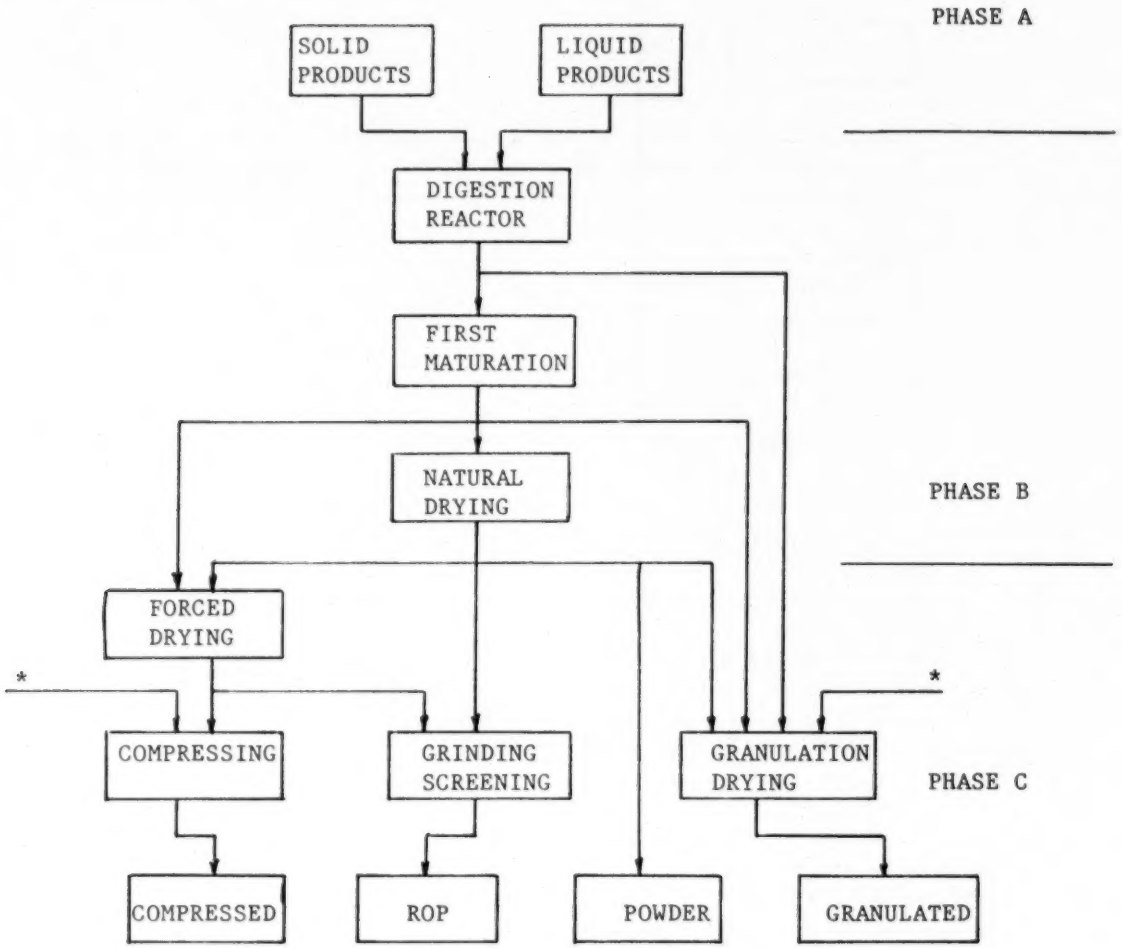
* O.P. = Other Products :
NH_3
Ammonia salts
Surfactants
Calcium salts
etc.

PHASE OF PREPARATION OF THE SOLID PRODUCTS



* O.P. = Other products :
Potassium salts
Ammonia salts
Calcium salts
Mg oxide and salts
etc.

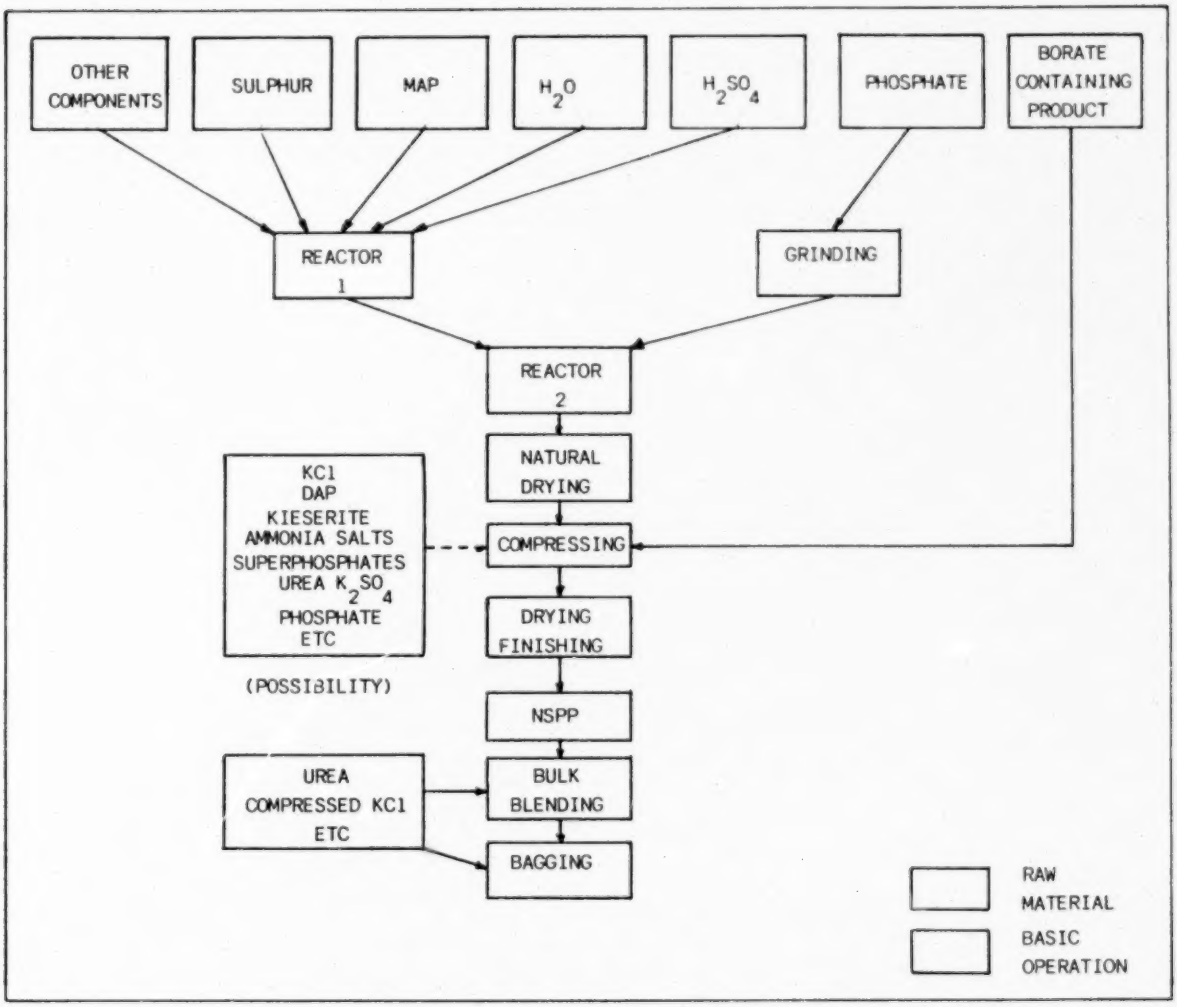
REACTION PHASE AND PRODUCTION OF FINAL PRODUCT



* OTHER SOLID AND LIQUID RAW MATERIALS

OUTLINE FOR WEST AFRICAN COUNTRIES

LAYOUT OF PRODUCTION



Workshop 1

Workshop 2

Workshop 3